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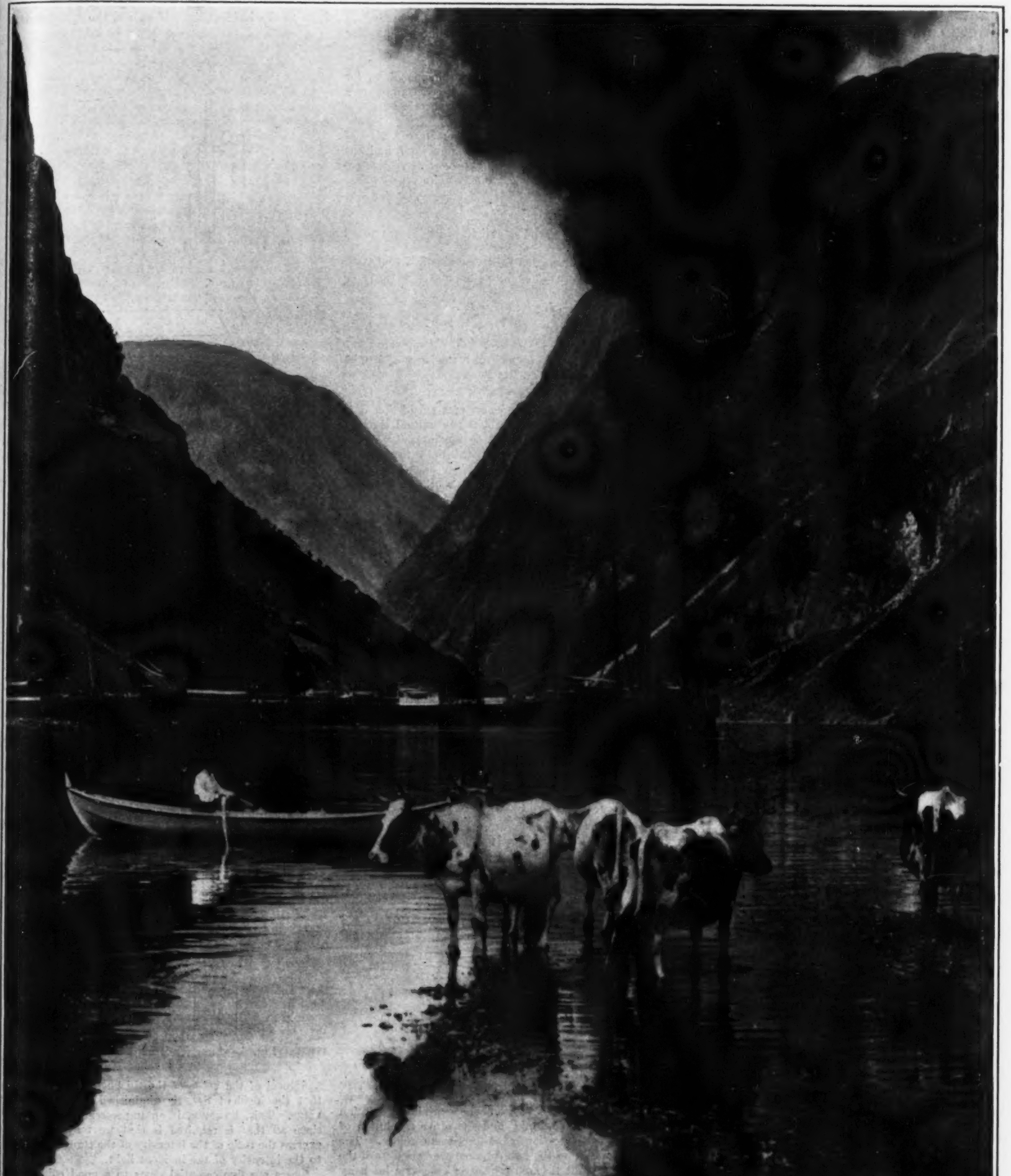


Gudvangen's outlook over the Naerofiord, where the sea reaches far in among the mountains of Norway.

FIORDS AND OTHERS INLETS OF THE SEA.—**[See page 189.]**

Quantitative Colorimetric Analysis—I*

Its Theory, Laboratory Methods and Apparatus

By G. A. Shook

THERE is to-day unfortunately no satisfactory explanation of the ultimate nature of light. In all probability, however, light is some sort of a transverse wave motion, by the character of the medium through which the waves are propagated and the mechanism by which the waves are produced are questions still unanswered. Nevertheless the experimentally derived laws in this field are so well established that the lack of a fundamental theory is not felt practically.

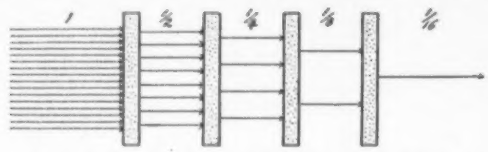


Fig. 1.—General representation of the laws of absorption of light.

When white light passes through blue glass it becomes blue. Whether the white light contains, as one of its components, the blue color or whether the blue glass manufactures the blue light out of the white, we are not able to decide with so much confidence as the ancients or the philosophers of Newton's time. Yet the fact remains and there is never any exception to it.

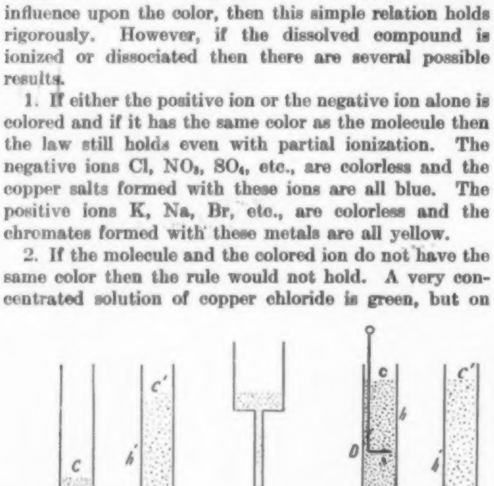
We are still farther from satisfactory theories when we come to the case of colored solutions, due to the numerous exceptions to all the simple hypotheses that have been proposed. These hypotheses are probably correct, but due to such disturbing influences as incomplete ionization and chemical reaction they cannot be universally verified. Nevertheless as far as practical colorimetry is concerned, experimental errors are generally greater than errors that might arise due to the departure from fundamental colorimetric laws.

When a colored compound is dissolved in a colorless solvent the extent to which the solution is colored depends upon the concentration, or the mass of the solute per unit volume of the solvent, and there is a very simple relation between the two factors. A thickness of 10 centimeters of a 20 per cent solution will produce the same light absorption as 20 centimeters of a 10 per cent solution of the same compound, etc.

If the molecules of the dissolved substance are not dissociated and if furthermore the solvent exerts no influence upon the color, then this simple relation holds rigorously. However, if the dissolved compound is ionized or dissociated then there are several possible results.

1. If either the positive ion or the negative ion alone is colored and if it has the same color as the molecule then the law still holds even with partial ionization. The negative ions Cl, NO_3, SO_4, etc., are colorless and the copper salts formed with these ions are all blue. The positive ions K, Na, Br, etc., are colorless and the chromates formed with these metals are all yellow.

2. If the molecule and the colored ion do not have the same color then the rule would not hold. A very concentrated solution of copper chloride is green, but on dilution the color changes to blue and remains blue as long as the dilution continues. Consequently the law would hold if we considered only dilute solutions.



Figs. 2A and B.—Simple types of colorimeters.

3. In the case of two colored ions, neither ion being colored the same as the molecule, for example H_2, Fe, Cu_2, the law would not hold except for dilute solutions, i.e., complete ionization.

The color of the ion may be different for different electrical charges; for example, the iron ion in the ferrous condition is green, while in the ferric condition it is yellow.

* Reproduced from *Metallurgical and Chemical Engineering*.

It might seem at first sight that any method for determining the concentration of a salt by means of its color would be unreliable, but in practice all these difficulties are not met with at once. In most cases we are dealing with dilute solutions or at least with a limited range of concentrations. It will be subsequently shown that in refined work it is not difficult to determine just how far the law holds for any particular case.

LAW OF LIGHT ABSORPTION.

Whenever light falls on any absorbing medium, for instance, a piece of colored glass or a cell containing a colored solution, part is reflected, part absorbed and the remainder transmitted.

Let the intensity of the light incident upon a layer of unit thickness of an absorbing medium be I and the intensity of the transmitted light be I_1. If the coefficient of transmission is a, we may write

$$\frac{I_1}{I} = a \quad \text{or } I_1 = Ia$$

a is that fraction of the incident light which is transmitted by unit thickness.

Now if this transmitted light traverses a second layer of unit thickness it will again be diminished in the same ratio, hence

$$I_2 = (I_1 a)a = Ia^2.$$

For three layers

$$I_3 = (Ia^2)a = Ia^3.$$

Therefore, if the light traverses a thickness of h units the transmitted light, I_h, has the value

$$I_h = Ia^h \qquad (1)$$

For example, if the coefficient of transmission a is ½, then the intensity of the light transmitted through one layer of unit thickness is ½ the intensity of the incident light. If this transmitted light traverses a second layer, ½ is again transmitted so that we have left only ¼ of the original amount of light. If the light passes through three layers we have ⅛ left and for four layers only 1/16 or $(\frac{1}{2})^4$ remains, etc. (Fig. 1.)

For a second absorbing medium

$$I_h' = Ia'^{h'}$$

and if the transmitted light is the same in each case $I_h' = I_h$, whence

$$a^h = a'^{h'} \qquad (2)$$

Now let b represent the transmission coefficient for a unit layer of a colored solution of unit concentration (1 g. of solute dissolved in 1 cc. of solvent). We may now write

$$I_1 = Ib,$$

and if the concentration is doubled, i.e., if the number of absorbing molecules is doubled, then

$$I_2 = (Ib)b = Ib^2.$$

Therefore, if the light passes through a unit layer of concentration c it follows that

$$I_c = Ib^c \text{ or } \frac{I_c}{I} = b^c. \qquad (3)$$

For a different concentration c' of the same dissolved substance we may write

$$I_c' = Ib^{c'}.$$

Since we have unit thickness in each case, $h = h'$, whence

$$I_c = Ib^c = Ia$$

and

$$I_c' = Ib^{c'} = Ia'$$

$$b^c = a \text{ and } b^{c'} = a'. \qquad (4)$$

From (1) it follows that

$$\frac{I_h}{I} = a^h = (b^c)^h = b^{ch}$$

This is known as Beer's Law.

Combining (2) and (4) we obtain the relation

$$b^{ch} = b^{c'h'}$$

whence

$$ch = c'h' \qquad (5)$$

Equation (5) forms the basis of the theory of all colorimeters. Light of the same intensity is caused to pass through two suitable vessels; one contains a solution of known concentration c' and the other a solution of unknown concentration c of the same solute. The heights h and h' of the two columns are varied until the transmitted light through each is of the same intensity and then the heights are measured. The unknown concentration may then be determined by means of the simple relation.

$$c = \frac{c'h'}{h}$$

There is another class of instruments which is used for determining concentrations, known as spectrophotometers. A spectrophotometer simply compares the intensity of two light sources for some particular color. From (3) it is seen that if the ratio of the transmitted light to the incident light is known, the concentration may be estimated.

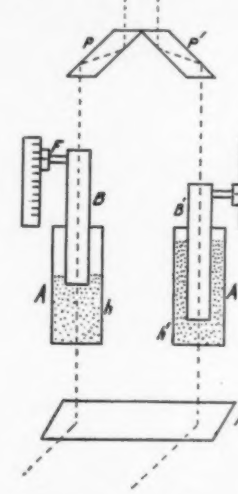


Fig. 3.—Duboscq colorimeter.

Equation (3) may be put in the form

$$\log \frac{I_c}{I} = c \log b = kc \qquad (6)$$

where k is a constant for any particular wave length of light and any particular substance in solution.

Equation (6) simply means that the logarithm of that fraction of light transmitted by a unit layer of a colored solution is directly proportional to the concentration of the solution. This unit thickness may be 1 centimeter or any other convenient width of containing cell.

For simplicity we will call the negative logarithm of the ratio $\frac{I_c}{I}$ the *extinction coefficient*, so that

$$e = -\log \frac{I_c}{I}$$

The logarithm of a fraction is, of course, negative, hence, by prefixing the negative sign, e becomes a positive quantity. Equation (6) may now be written

$$c = Ae$$

We will moreover call the constant A the *absorption ratio.*

The form of the expression for the determination of c depends, of course, upon the type of instrument used, and this will be fully considered in a succeeding issue of this journal.

The extinction coefficient is sometimes defined as the reciprocal of the value of the thickness of a layer such that the incident light is diminished to one-tenth its value. This, however, is an unnecessary complication since all that is required is that we may be able to express the ratio of the intensity of the transmitted light to the intensity of the incident light.

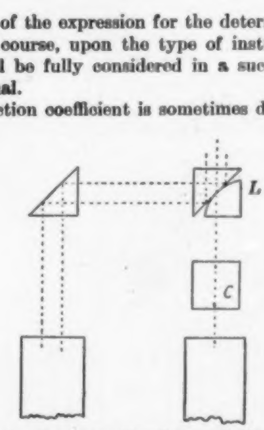


Fig. 4.—Lummer-Brodhun colorimeter.

There are five essential parts to a good colorimeter, vz.:

1. Containing vessels for the standard and unknown solutions.

2. A method for adjusting the height of one or both of the two liquid columns.

3. An accurate means for measuring the heights of the two columns.

4. A device for bringing the two fields of view close together in order to determine when equality of brightness is obtained.

5. A source of illumination.

The simplest type of colorimeter, but one which is too crude for accurate work, consists merely of two cylindrical glass jars or graduates placed upon a white mat surface, to give uniform illumination. One graduate is filled to a convenient mark with the unknown solution and a standard solution is poured into the other graduate until the two top surfaces of the liquids appear equally bright. Knowing the two heights the unknown concentration may be readily calculated.

Of course, the standard solution may be filled to a given mark in one cylinder and the unknown poured into the other cylinder until a balance is effected.

Sometimes one jar is filled to a given mark (100 cc.) with an unknown solution and the other jar is filled with a stronger solution of known concentration to a given mark (10 cc.). The known solution is then diluted until both jars appear to have the same intensity of color and the required amount of dilution necessary to effect this balance can be estimated by observing the volume of the standard solution.

In such cases the diameter of the two cylinders must be equal, but when we are concerned only with the heights of the liquid columns this is not necessary.

A slight improvement upon this simple type of colorimeter is to provide the jars with stop cocks for drawing off the solutions. If one of the jars, say the one containing the known solution, is connected to a reservoir, Fig. 2*a*, which can be gradually raised and lowered, it will greatly facilitate the operation of making an intensity balance.

A still better arrangement is a tubular reservoir provided with a glass plunger, in which case the solutions come in contact with glass only.

Instead of changing the height of the liquid a white disc *D*, Fig. 2*b*, may be lowered into one jar, thus changing the effective length of the liquid column.

Another scheme which is often used is to fill a number of jars, all to the same mark, with standard solutions of varying concentrations. A similar jar is then filled to the same mark with the unknown solution and its concentration may be roughly estimated by comparing the intensity of its color with the standard solutions.

The chief objection to all of these methods is that only a rough estimation of the equality of brightness can be made due to the fact that the two fields of view are not close enough together. This objection is overcome in the following instruments:

DUBOSCQ COLORIMETER.

This instrument is shown in schematic form in Fig. 3. The standard and the unknown solutions are placed in two glass jars, *A* and *A'*, into which dip two solid glass cylinders, *B* and *B'*. Each cylinder is actuated independently by means of a rack and pinion, and to each pinion is attached a fiducial mark *F* which moves over a graduated scale. The heights *h* and *h'* may be read directly from the scales.

Daylight is diffusely reflected from an opalescent mirror *M* to the jars *A* and *A'*, is then transmitted through the cylinders *B* and *B'* and by means of the reflecting prisms *P* and *P'* finally reaches the eye.

By means of these two prisms, which are cemented together, the two fields of view are brought in close contact so that the observer can make an accurate intensity balance. The faces of the prisms, the ends of the cylinders and the bottoms of the jars are all optically plane, so that the field of view is very clear and uniform, which is essential, if accurate work is required.

The eye is not able to make any estimate whatever of the relative brightness of two illuminated fields, but it can accurately determine when two fields are equally bright if favorable conditions obtain.

The two fields must be uniformly illuminated throughout and must not be separated by a line of any appreciable width. When the eye is required to move from one field to the other, as in the case of the crude colorimeters, it loses the impression of one field before reaching the other and the accuracy of the judgment is greatly impaired.

In some forms of colorimeters both eyes are used, but such a method is unreliable.

It is moreover desirable to have just sufficient light enter the eye to prevent fatigue. If the field is too dark the eye is constantly under a strain due to an abnormal dilatation of the iris and if it is too bright an abnormal contraction is necessary.

To make an accurate intensity balance, means must be provided for varying the intensity of one or both of the fields in a continuous manner. One field should be made alternately brighter and darker than the other, diminishing each time the difference in intensity until no difference can be detected. Care must always be taken in making a setting, but the operation of making one field brighter than the other must not be prolonged until the field appears blurred, for then the eye has lost its maximum sensitiveness.

A colorimeter similar to the Duboscq, due to Stammer, is sometimes used for beer analysis. The standard solution is here replaced by a colored glass and the containing vessel is moved instead of the dipping cylinder. This instrument, however, is not applicable for all adulterations.

Müller has designed a similar apparatus for water analysis. It has a 10-centimeter tube which is filled with water, to which Nessler's reagent has been added. The balance is made by means of gold-colored glasses 1.5 millimeters in thickness. The equivalent effect of the glasses is given in the following table:

1 glass is equivalent to	0.02	mg. of NH_3 in 100 cc. of H_2O.
2 glasses are equivalent to	0.05	
3 glasses are equivalent to	0.07	
4 glasses are equivalent to	0.10	
5 glasses are equivalent to	0.15	
6 glasses are equivalent to	0.20	

WOLFF COLORIMETER.

The essential difference between the Wolff colorimeter and the Duboscq is that the former is not provided with the dipping cylinders. In order to bring the two fields to the same intensity, liquid is drawn off from either vessel.

It is somewhat easier to calculate the concentration if one jar is filled with the weaker solution up to the 100 mark and the stronger solution drawn off. This arrangement has the disadvantage that one cannot make a fine adjustment of the two fields as in the Duboscq. In order to repeat a setting it is necessary to pour some more solution back into the vessel or to disturb the solution which is at the 100 mark.

Since the accuracy of the concentration, finally determined, depends primarily upon the accuracy of making a good photometric balance, this is a weak point in this type of apparatus. It does, however, have this slight advantage, that the jars do not have to be made as long as the ones used in the Duboscq instrument since there is no liquid to overflow.

In some types of the Duboscq colorimeter, this difficulty is overcome by making the upper part of the jars of much larger diameter than the lower part.

In the Duboscq instrument, the light entering the two vessels does not come from the same part of the mirror and, therefore, it is necessary to bring the two fields to the same intensity before the solutions are poured into the vessels. In the Wolff instrument, however, the light which reaches the two vessels is reflected, by means of a Fresnel double prism, from approximately the same region so that the two fields are practically always the same in intensity.

A smoked glass is sometimes used to diminish the intensity of the field, thus enabling the observer to make a better balance. The bottom caps of the two glass tubes may also be removed for cleaning.

The above types of colorimeters involve the essential features, although there are a number of other colorimeters which employ different methods for changing the intensity and different devices for producing good fields.

The most sensitive photometric screen is undoubtedly the Lummer-Brodhun. The optical system for bringing the two fields together, when this photometric screen is employed, is shown in Fig. 4.

L is the Lummer-Brodhun prism and *C* is a compensating cube, which is inserted in order that the path of each beam may have the same optical length. This arrangement could of course be used on any colorimeter employing two vertical vessels.

EXTINCTION COLORIMETERS.

There is another class of colorimeters sometimes employed for turbid solutions. Instead of comparing the intensity of the light transmitted through a standard solution with the light transmitted through an unknown solution the light through a single column is made extinct by varying the length of the column.

A turbid solution of known concentration is placed in a suitable vessel and the observer views a standard candle or a lamp of constant intensity through this column of absorbing material. The length of the column is increased by pouring in more of the turbid solution until the light just becomes extinct and then the length of the column is noted. If the same operation is carried out with an unknown solution its concentration may be easily calculated.

Writing Beer's Law for the two cases we obtain

$$\frac{I_h}{I} = b^{ch}$$

and

$$\frac{I_h'}{I} = b^{c'h'}$$

But the fraction of the incident light which reaches the eye in each case is approximately the same, hence

$$\frac{I_h}{I} = \frac{I_{h'}}{I}$$

$$ch = c'h' \tag{7}$$

Absolute darkness is not, of course, produced in each case when the light disappears, consequently I_h is a finite quantity, though very small.

This method has the advantage that no standard solution is required and the necessary apparatus is much simpler than that which is necessary for the comparison of the intensities of two fields.

Colorimeters based upon this principle cannot, however, be used for accurate work since one is not able to reproduce the extinction point with the same accuracy that one can reproduce the equal-intensity point.

Moreover, the personal equation must be reckoned with, since different eyes vary greatly in this respect.

Again, the standard lamp must be kept constant, which is not always possible without complicated auxiliary apparatus.

This method has been used extensively for the rough estimation of the amount of sulphate in water, urine, coal, cement, etc., and in fact in any case where a fine precipitate could be easily formed.

The early investigators using this simple method observed that the product of the concentration and the height of column necessary to produce extinction is a constant, but aside from this they gave no theory of the method. Some of them state that it is necessary to keep the light constant and others state that this precaution is unnecessary. The column of liquid must always be lengthened until the lamp just disappears, but manifestly a strong light will require a greater length of absorbing material than a weak light.

Evidently it is not necessary to restrict this class of analysis to the extinction colorimeter since any of the determinations may be made by means of a spectrophotometer with much greater accuracy. The colorimeter is not so well adapted to this sort of work as the spectrophotometer, due to the fact that the former requires a much longer layer of absorbing medium and the consequent loss of light is too great.

There are a number of colorimeters on the market which are designed for special purposes, but the fundamental principle involved in most of them is the same and consequently one instrument, with slight modifications, can be used for almost all purposes.

There is no one colorimeter which embodies all of the best features. The best method for bringing the two fields together is that shown in Fig. 4, while the best method for varying the intensity and determining the heights is that used on the Duboscq colorimeter.

The containing vessels should be easily removable for refilling and cleaning.

Since we are concerned only with the thickness of the absorbing layer and not with the volume of the solution, it is not necessary that the two vessels have the same diameter nor that either has a uniform cross-section.

Metallic scales and delicate optical parts should be well protected from the action of salts.

Before taking any observations upon a solution one should make sure that both fields of view are equally illuminated. They can be brought to equality by shifting the colorimeter slightly or by rotating the illuminating mirror.

(To be continued.)

Invasion of Oysters from Portugal

PORTUGUESE oysters, which according to the opinion of zoologists do not even belong to the properly called species of oysters, but to the gryphæa species, are threatening to invade the French oyster beds. M. Edmond Perrier, Director of the Natural History Museum, recalls to mind that the more robust Portuguese oysters have, in the region of Arcachon, supplanted the native oysters, which have a much finer taste. The Portuguese oysters are likewise attacking the Marennes oysters that are so highly appreciated. But it was thought that the danger was limited. It was not thought that the Southern gryphæa could become acclimatized on the Brittany coasts. Now such is not the case. The Portuguese oysters can very well live on the Brittany coasts, and they are threatening to gradually take the place of the oysters of Cancale that have a much better taste and are more appreciated. M. Dantan, who has made numerous studies on these molluscs, indicates, however, a means which will enable oysters cultivators to guard against the danger. This means is founded on the notable difference between the embryo of the ordinary oyster and of the Portuguese oyster. The embryo of the ordinary oyster develops inside the shell, whereas the embryo of the Portuguese, more undisciplined, comes out of the shell and goes and fixes itself on the collectors; that is to say, on the posts, fascines, tiles that are employed to collect the "naissin" or spawn. Indeed, the larva only develops on the surface. If, then, the collectors are driven down deeper, the embryos of the Portuguese oysters will no longer be able to live. The peril will thus be averted.—*Chemical News.*

NEW JERSEY has a timbered area of about 2,000,000 acres, on which the timber is worth about $8,500,000 on the stump. It is mainly valuable for cordwood.

Empounding the "Medina Dam," near San Antonio, Texas. Taken shortly after completion, and showing one of the examples of how Texas increased its irrigated area three hundred per cent in the past decade.

Conserving Flood Waters in Texas

Increasing the Irrigated Area of Our Biggest State

By Z. E. Black

NOT all the December, 1913, rains in Texas, which were said to have been the heaviest in 40 years, and which resulted in 177 deaths and a property loss of $8,541,755, went down a path of destruction to uselessly augment the Gulf of Mexico. Millions of gallons were empounded behind the Medina Dam, which is a substantial example of the headway the modern doctrine of conservation of flood-waters is making in the semi-arid Southwest.

This dam is located 40 miles west of San Antonio on the Medina River, which normally is little more than a brook, but drains an enormous water-shed. It is a public utility enterprise and was begun and virtually completed by English capitalists (the Pearson interests) in 1912, thus setting a world's record for dam construction of this magnitude. The empounding dam is 1,580 feet long at the crest, 164 feet high above the river bed, 128 feet wide at the base and 25 feet wide at the top. All possible danger from seepage has been forestalled by leaving a series of drainage holes leading to the bed of the river, beneath the dam; these holes being necessary for an examination at any time by means of tunnels which extend from one end of the dam to the other.

The diversion dam, also of concrete, is 500 feet long and 48 feet wide, and is located 4 miles below the main dam. The diversion dam will turn the water into the main canal which has a tortuous passage of 29 miles before it reaches the lands, passing through concrete walls, deep cuts, 11 flumes and 2 monster siphons. The capacity of this canal is about one half the normal flow of the Rio Grande River.

The empounding dam backs water up the canyon for 18 miles, creating a lake that carries from a few feet in depth to 160 feet. The capacity of the reservoir is 300,000 acre feet or about 100,000,000 gallons of water, an ample supply for the irrigation of 60,000 acres for 2½ years, even if not a drop of rain falls during that time. The cost of the project runs well into the millions, being almost as large as the prominent Roosevelt Dam.

There are now more than 130 feet of water against the dam, an amount equivalent to all the water in the Panama Canal from ocean to ocean, or a sufficient quantity to fill a canal from New York to San Francisco; length 3,180 miles, 30 feet in width and 11 feet in depth. And the major portion of this supply was conserved from the December precipitation. The land to be irrigated is largely within sight of the lights of San Antonio, and irrigation starts this year.

It is estimated that the land subject to this dam will in time support a population of 300,000, whereas it now sustains under "dry farming" fewer than one fifth of that number. The Government has no homestead lands in Texas, hence the stretching of the soil—making the biggest State bigger—by means of large irrigation projects, must be looked forward to by means of private capital, and a number of other dams are being planned for semi-arid southwest Texas.

Construction view of second reinforced concrete siphon recrossing the Medina River. The river bed is just out of sight under the bluff. The twin siphon tubes have a 7-foot diameter, will be 1,350 feet long and will deliver 600 cubic feet per second. A second siphon of similar nature crosses the river about a mile above this view.

Front and back view of the new swaging machine.

Swaging Machine With Semi-Automatic Holder

Designed for Accuracy and Economic Working

THE functions of the swaging machine and holder, illustrated herewith, are to feed, reduce to size, and automatically withdraw from the machine dies, solid stock, round, hexagonal, square or other sections on which one plain unreduced butt or end and a reduced shank or blade are required, such as on valve push rods, nut tapper taps, single-butt automobile spokes, gun cleaning rods and similar parts ranging up to ½ inch diameter and from 8 to 14 inches long, the operator's duties consisting only in loading, starting and unloading the holder, the swaging, feeding and withdrawing of the work from the dies being done automatically.

The reductions are accomplished without wasting or removing the surface of the stock. The savings in expensive material and in time of production are very large, as will be seen by a careful study of the time of operation and by comparing the lengths of the blanks with the lengths of the swaged samples in the diagram. In addition, a great saving of grinding expense is obtainable as the machine brings the work very close to finished size, requiring but a minimum of grinding expense to produce absolutely accurate work. For many classes of work the swaging is so close to size that all grinding may be eliminated.

For accommodating longer lengths and greater diameters or for reducing tubing, the same type of feeding and withdrawing mechanism can be adapted to other types of swaging machines. When equipped with high-speed steel dies 2½ inches long, the machine shown reduces cold rolled steel stock 0.311 inch in diameter down to 0.250 inch in two operations, the feed being accomplished at the rate of 30 inches per minute at each operation and the piece withdrawn at the rate of 60 inches per minute. Faster feed and return speeds may also be employed if the size and character of the stock will stand them.

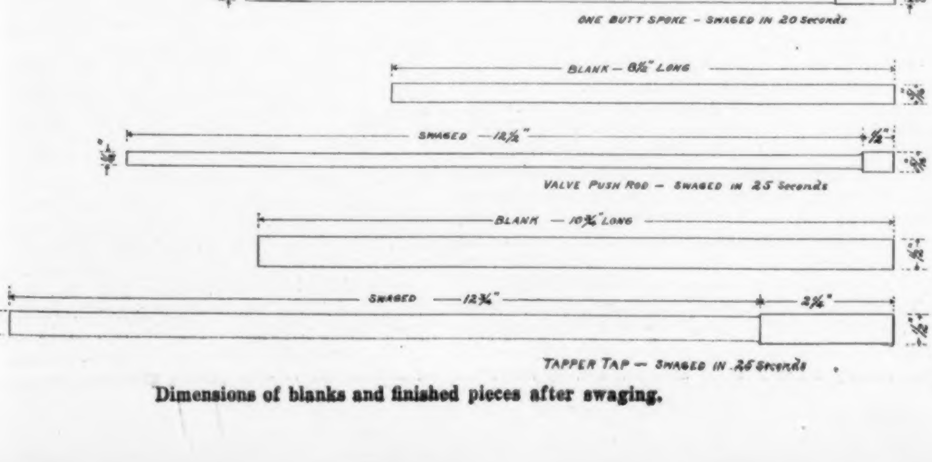
The machine shown is so built that the size to be swaged with it may be controlled very closely, producing work of uniform diameter for a high surface finish. Throughout the entire construction the machine is proportioned very liberally to make it an exceptionally rigid unit which enables an unskilled operator to obtain and maintain steadily a high degree of accuracy of swaging and output at a minimum of upkeep expense and without injury to the machine.

The spindle, which is the vital element of the machine, is made unusually large and heavy, of hammered steel turned and ground, bored for its entire length so that long pieces may pass through and beyond the dies. The spindle is slotted across the enlarged end to receive a pair of hammer blocks and dies, and all sides of the slot being lined with hardened surface ground steel plates, securely riveted to the sides of the spindle slot, forming a superior construction which practically incloses the dies and hammer blocks in a hardened steel box maintaining the dies in true alignment and insuring long life to the surfaces in contact.

The hammer blocks carry on their outer ends two hardened and ground steel rolls which come in contact during every revolution of the spindle with all the hardened steel rolls located around the head of the spindle in the machine head. As the head rolls do not revolve slowly around the spindle, but are in fixed seats in the head, at every revolution of the spindle a positive number of sharp, quick, ringing blows are delivered by the dies to the stock being swaged, producing a permanent set in the metal, and imparting a high surface finish which eliminates grinding expense through the impact of the revolving hammer block rolls with the fixed head rolls.

The dies are of large, heavy section, 1¼ inches wide by 7/8 inch high by 2½ inches long, and when made of high-speed steel, maintain their size for a long time with but a minimum attention. These dies may be quickly taken out by removing a screw plug with a special wrench furnished with the machine.

To control the proper die opening and maintain the reduced size wanted on the stock, two conically pointed screws are let into the front plate on the slotted end of the spindle and project into corresponding holes in the end of the hammer blocks. Washers of the proper thickness are used under the head of the screws to retain the distance to which the conical points of the screws will enter the hammer blocks. By adjusting these conically pointed screws in or out, different amounts of opening between the dies are obtained. These settings do not work loose while machine is running, an unskilled operator being easily able to obtain uniformly accurate work.



Dimensions of blanks and finished pieces after swaging.

An extra long bearing is bored out for the spindle through the head and loose floating sectional cast-iron perforated bushings are used over the spindle, serving to greatly decrease the surface velocity and increase the wearing surface. These cast-iron bushings are perforated all over and the oil holes act as small reservoirs for the oil and serve to better distribute this oil all over the spindles as the bushings gradually revolve with the spindles.

The flywheel is heavy and its hub split and through-bolted to the spindle with two ¾-inch bolts. It is also keyed. This arrangement has been found very effective in preventing the flywheel from working loose. At the rear end of the spindle a clamp nut is provided that serves both as a means of taking up end play which might occur on the spindle from long service and for holding the flywheel endwise in position. This construction should be very closely noted because it has a great bearing on the life, accuracy and service which a swaging machine gives.

An automatic oil-feed pump driven from the main spindle circulates oil through the running parts of the machine and is connected to a large oil reservoir with a strainer concealed in the base of the machine, enabling the same oil to be used over and over. The ample capacity of this reservoir permits running the machine for a long time with only periodical attention to the oiling.

The holder consists of a rigid ribbed projecting rail bolted to the front of the machine head providing long bearings on machined and scraped slides over which a cross head and saddle carrying an interchangeable self-centering spring chuck with hand lever tightener for holding the stock firmly even with very short grip during the swaging operation travel in a reciprocating manner, feeding the stock to be swaged when the cross head pauses slightly to allow the stock to be swaged neatly against the shoulder joining the unswaged with the swaged portion, when it starts on its return stroke.

As it recedes at twice the feeding speed, the stock is automatically withdrawn from the dies and when near the end of the return stroke the holder mechanism driving belt shifting device operates, slipping the belt to the loose pulley at the rear, bringing the holder cross head to a stop in a loading position.

As the next blank is gripped by the chuck and bound by a one quarter turn of the band lever, the operator shifts the driving belt to the tight pulley by the hand belt slipper, starting cross head again on the feeding or forward stroke, this cycle of motions being repeated for every blank. The cross head can be set at any desired position on the holder rail and the forward or backward travel of this cross head varied at will according to the length of the blank before and after swaging, to vary the length of the swaged portion or the length of the butt

and to avoid lost travel of the cross head, producing uniform work without any attention from the operator.

The length of the feeding and return strokes of the cross head are determined by the arc which the segment gear partly shown in the front view of the holder, and meshing into the rack cut on the under side of the cross head saddle, describes as it is actuated by a straight line movement of an adjustable stud on the large lower cross head.

By setting this stud at different positions in the ways of the segment gear arm the length of the arc can be varied at will. On the rear of this lower cross head another stud is provided, carrying a roller engaging in the path of a large cylinder cam which is rotated by a worm wheel and worm driven through a reducing gear and tight and loose pulleys from the countershaft.

The floor space occupied by the machine is 85 inches by 40 inches; its weight about 4,109 pounds.

The Need of a Traffic Census

Its Importance in the Determination of a Highway Policy

By J. Pease Norton, Ph.D.

In the early history of railroads, when locomotives were little, if any, larger than the automobile trucks of the present day, although far more ponderous in any fair comparison, thinkers of those days likened railroads to public highways, and talked and wrote regarding the coming area of iron *rail* roads to be built by the Government, roads upon which any man might operate his private locomotive. But the evolution which followed in this field of transportation was far different from that originally contemplated by those early thinkers.

EARLY CONCEPTIONS OF A HORSELESS AGE.

They had looked forward in the beginning to a horseless age to follow with the development of the steam engine. They had believed that not every one, but very many persons would come to own steam engines of their own. Future *rail* roads were described as public highways—common property. But, owing to the relatively heavy weight of the steam engines of those days, *rail* roads were found to be a necessity. The steam engine was barred from the highways by this high ratio of weight to power.

EVOLUTION AWAY FROM MULTIPLE INITIATIVE.

The laying of *rail* roads required vast outlays of fixed capital, and as a result corporations took over the work of construction. Finally, monopoly of operation was found to be essential to safety on a *rail* road in the operation of which a systematic handling of brakes was a *sine qua non*. In short, the steam roller which labors over the highways was the closest approach in the consequent evolution to the ideas of a horseless age once held by those early thinkers. Now after many years we are returning to those earlier conceptions.

ON THE THRESHOLD OF THE HORSELESS AGE.

By new inventions, principally in the direction of reducing the ratio of weight to power and by utilizing the principles of resiliency in rolling contact, there has been created a new mechanism in transportation which does not require a *rail* road, and, therefore, again brings into play those important economic principles of progress which are inherent in multiple initiative. But our new mechanism in transportation, like the steam engine of earlier days, does require a better road surface than that given by much of the past and prevalent construction, which, nevertheless, we must credit with the creation of the vast network of highways now *gratis*—a truly great heritage handed down from the past. We start with a network of highways, already located and partially constructed, possibly two million miles or five times the mileage of the roads of France. The preliminary work of grading has been done. The next great work consists in their improvement.

THE MAGNITUDE OF THE PROBLEM.

Even now we are only on the threshold of the horseless age. At present we may estimate roughly that six billions are invested in other means of transportation upon the highways than by automobiles; for instance, in horses, mules and the necessary equipment. Against this sum we may estimate six hundred millions to one billion invested in automobiles. We anticipate that the conversion of capital now in horses and wagons over into automobiles will proceed rather rapidly during the next census period. Possibly some part of the capital now invested in railroads and trolley lines will be converted.

The radius of action of the owner of a horse and wagon may average 20 miles or 40 miles to a day's journey, 20 going and 20 returning. If we assume for the average day's journey of an automobile 120 miles, in a certain sense we are tripling the radius of action of the man. This insures a surprising expansion in traffic density, all in addition to the probable lessening economic cost of transportation on the roads, which would naturally stimulate greater consumption of road mileage. Assuming during the coming five years a continuance of the normal increase of the past six months, at this rate of increase there should be 2,500,000 automobiles, possibly 3,000,000 in 1918. At $600 value, this will represent an investment value of $1,500,000,000. Allowing only $50 a year for tires, we have here an annual outlay of $150,000,000 for this tire item alone. With proper surfacing, the tire mileage can be greatly increased. To save one half this waste of tire wear, which comes largely from bad resurfacing, would mean within a few years at least $75,000,000 annually, or enough at 5 per cent to pay the interest on $1,500,000,000 of bonds issued for road improvement.

As we look ahead and consider the magnitude of these figures, hardly overestimates, and realize the possibilities, we may with a fuller realization of the needs of the immediate future dismiss the statistics which after all are offered only to suggest the need of careful planning—intelligent planning of our future national highway system.

During the last ten years it has been estimated that $1,000,000,000 have been expended upon the highways of the United States. It is seriously open to question whether or not a large per cent of this great sum has not been thrown away without results.

The evolution of the railroads—large sized units working into larger and fewer units by combination—has produced increasing centralization and much public discontent over the rates. The automobile places transportation for at least 200 miles again in the hands of the people.

ECONOMIC CRITERION FOR NATIONAL APPROPRIATIONS.

It goes without saying that we anticipate in the development of the coming national highway system a series of vast outlays by the National Government, supplementing even larger appropriations by State governments and added to the contributions of the municipalities and towns. Obviously, the national appropriations should be divided among the States upon the basis of population, subject to application by the States and upon condition of a State appropriation. Further, perplexing questions regarding the uses to which the national funds shall be put as well as regarding the control of the work—all these questions must be settled by agreement in Congress.

From the standpoint of economics, the problem seems to require a criterion for the distribution of a large amount of fixed capital which should be invested in such a way that the outlay shall be most economically managed in order to secure maximum returns—not only with respect to the present trouble, but also to the future maintenance.

As in the evolution of the railroads, differentiation was early established between feeders and main lines, and later between main lines and trunk lines, so in the highway system we must differentiate between feeders and main lines, main lines and trunk lines. As in railroads the density of traffic determined the classification of the given railway track, so the density of traffic should decide the classification of the highways.

TRAFFIC CENSUS AT SELECTED POINTS.

Until recently this idea was hardly considered by highway officials, if at all. The idea of a traffic census in an informal way is not new. Vehicle counts have been made within recent years in Paris, London, Chicago, New York, New Haven and other cities, some by semi-official, others by private individuals. But the idea, or rather the importance of the idea of a formal traffic census, is not yet perceived completely by those who have this work in charge.

Two elements destroy the capital invested in a highway—time and traffic. Against time the principal defenses are road drainage and foundation. Against traffic, given good foundation and drainage, the principal defense is in the surface. Given good, equally good drainage and foundation, a dollar invested in a given surface should give different results, allowing for maintenance, for different traffic densities. For different traffic densities a dollar in macadam may prove more economical than a dollar in some more permanent surface when the cost is reduced to the traffic unit. In other words, to invest economically the money which is to be appropriated and to secure maximum returns measured in utility to those who actually use the roads, we need to know where the traffic is at the present time and also the relative density.

A STANDARD VEHICLE COUNT BLANK NEEDED.

The writer feels that there is no more important work for the Office of Good Roads to undertake than the preparation of a standard vehicle count blank which shall classify traffic both by direction and by nature of vehicle. Such a standard blank should be arranged for general use at intersections of main lines throughout the States.

Once a standard vehicle count blank is adopted and generally furnished to towns, cities and States, the first question which will be asked should be the average present vehicle count for the given highway. Once official statistics of vehicle counts are available, it will be easier to lay out intelligently national trunk lines in order to serve most efficiently the local as well as the through traffic.

THE PURPOSES OF NATIONAL APPROPRIATIONS.

The national appropriations for a given State should go to develop the natural trunk lines connecting the population centers of a given State with the population centers of the adjoining States. Such trunk lines should be models of permanent construction. The traffic census should determine where such work should begin—namely, where the density of traffic in a given State is the highest. The traffic census will determine the width of the road and the nature of the surfacing—namely, the most economical for the given traffic.

PLAN FOR A TRAFFIC CENSUS.

An interesting and useful traffic census might be made upon a uniform radial basis. From a national standpoint, we are interested in trunk lines. Why not select cities of over 30,000 population, and taking business areas as centers describe circles with radii of 4, 8 and 12 miles. Let vehicle counts be made at the three circumferences where intersections are had with the principal radiating roads. We should then have an excellent idea of the through currents of traffic as well as the relative importance of the highways. From such records engineers could select through routes which would serve most efficiently local traffic and at the same time act as links in through routes or trunk lines.

To relieve the growing congestion at business centers through traffic should be sent around rather than through the business areas. A belt-line boulevard following the circumference of the four-mile radius might solve the problem very satisfactorily for smaller cities. This is a possible solution, taken in connection with plans of municipalities which often embrace an encircling boulevard or system of encircling streets joining a series of city parks—all of which makes for an ideal suburban development.

A SAMPLE VEHICLE COUNT BLANK.

Along with his study of railroads and other methods of transportation, the writer has collected some data in regard to traffic density upon the streets of cities. On the chance that some of these statistics may prove of passing interest in connection with the subject of relative densities, I have selected a few representative averages showing vehicle count per hour for various streets. Before presenting this table, which deals largely with the writer's own enumeration, traffic experts may be interested in the headings used in the vehicle blank devised by the writer for the use of his traffic enumerators. My traffic blank analyzes traffic by classes of commercial vehicles, by direction of traffic, by number of drivers, by number of horses and by a classification of nature of business. From such data, when cast into averages and percentages, excellent measures are afforded for measuring wear and tear upon surfaces as well as determining what classes of business will benefit most by the improvement of a given highway.

Inasmuch as statistics of traffic density which include a large number of pleasure or passenger vehicles do not carry the same weight of importance in the minds of business men, all passenger counts are omitted from the statistics given. The figures show the business man's use of the street for conveying goods.

For city streets there are two main classes—delivery wagons and trucks. Delivery wagons are classified into milk, post office, baggage, newspapers, provisions, department stores, express and miscellaneous. Trucks may be divided into merchandise, groceries, coal, building material, lumber, meat, dry goods, earth, ashes, street cleaning, brewery, fruit, ice and hardware.

Figures opposite headings give the average number of commercial vehicles passing given corners per hour.

Average of 1,000 corners in Manhattan south of 42nd Street	254 per hour
Average of 500 corners on north and south avenues of Manhattan, between 42nd Street and 125th Street	185 per hour
Manhattan, average of all corners of:	
First Avenue	272
Third Avenue	268
Fifth Avenue	311
Sixth Avenue	264
Seventh Avenue	255
Eighth Avenue	333
Average seven busy corners in Chicago	908
Average Fifth Avenue and 37th Street	1,160
Fifth Avenue and 32nd Street	1,050
Fifth Avenue and 29th Street	1,109
Average Temple and Chapel Streets in New Haven	190

Instructions for Use of Vehicle Count Blank: "Estimate weight of load in wagon. Write weight under proper head in first column. For empty wagons, write E; covered wagons, write C. Carefully note direction team came from and went to. Write in second column, under proper heading accordingly, N, E, S, W, NE, NW, SE, SW, EN, ES, WN, WS. For instance, the letters WS mean team first traveled west and turned south. Note also whether there are more than one horse and one man. If two men, place dot in third column, and if two horses place dot in fourth column. If three horses, place two dots in fourth column. If an automobile, enter letter A in fourth column. All heavy wagons carrying wholesale goods not known, enter under Merchandise. All delivery wagons which cannot be placed under proper headings, enter under Miscellaneous. Inspectors will call out and recorders copy.

"Each page of the traffic book must be filled in with name of the inspector and recorder, corner of streets by names, hour of count, date, special remarks."

Obviously, the above figures would be much larger if passenger vehicles were included. Thus, Temple and Chapel Streets, New Haven, rises to 430 instead of 190 when passenger and pleasure cars are put in.

It is probable that the types of road construction which most successfully withstand the tremendous wear of city traffic will prove the best for the national trunk lines. Statistics of life of surfaces for various traffic densities, based upon the experience of cities, should be assembled and reduced to tables. Thus, we need to know traffic density in order to select the most economical type of construction for the given density as well as to know what the life of surfaces is under various traffic densities.

Further, there is another side. To be able to present the nature of the commerce which passes over an important road, accurately classified, is an important help to secure popular support for appropriations in improvement campaigns. Business men need to know the exact figures fully to appreciate the importance of permanent construction. When the actual figures are at hand showing that a given stretch of 10 miles has a traffic density of 1,000 tons per day or 300,000 tons per year, or 3,000,000 ton-miles per year, 10 per cent coal, 5 per cent lumber, 15 per cent building materials and 20 per cent farmers' produce and the balance miscellaneous merchandise, all in addition to 4,000,000 vehicle miles of passenger and pleasure vehicles, the economic basis for a large appropriation or for the necessity of a bond issue can be perceived by everybody.

The problem requires the tabulation of empirical experience with various types of construction described in terms of traffic density. We need the empirical data expressed in traffic units. Some of these conceptions follow:

Vehicle count per hour at an intersection.

Average vehicle count per hour for a main line, based on vehicle counts at uniform intervals.

Classified vehicle count per hour, by types of vehicles, expressed in per cents.

Gross tonnage of all vehicles per hour, based on classified vehicle count, as a measure of wear and tear on surfaces.

Net commercial tonnage of vehicles per hour, as a measure of utility.

Durability of surface measured in years of life for a given density.

Annual road-mile cost of a given surface, based upon maintenance, interest upon first cost and sinking fund for replacement at expiration of life for a given traffic density.

Summary standard tables for various surfaces and various densities.

NATIONAL HIGHWAYS AND NATIONAL CONTROL.

Who shall control the location of the trunk lines which are to be financed by the national funds? What shall the nation receive for the national bond issue or appropriation? These are the questions which are now before Congress. The writer believes that Congress should be urged to place the great engineering force at Panama, now at liberty by the successful completion of that great work, upon this even greater undertaking, the perfecting of a National Highway System.

Congress should be urged to make an appropriation for a traffic census, in order that the army engineers or others who may have this work in charge may be able intelligently to select a system of military highways connecting the larger population centers of the various States together with a system of detours connecting trunk lines which do not pass through congested business areas of cities. Such a system of detours conveniently serves the quick movement of troops as well as the growing through-traffic now greatly impeded by the ever-present condition that State roads and turnpikes generally pass through the business centers of the towns, villages and cities.

CONTROL UNDER THE ARMY ENGINEERS.

In times of peace we further commerce by good roads. In times of war we make possible the rapid movement of supplies and troops. We shall place the highway problem upon a high plane of efficiency and at the same time greatly strengthen our plans for national defense by enlisting the army engineers in this tremendous task of planning the coming system of national military highways.

Why not link up parallel functions of the Government in co-operative effort? Why not empty the Federal prisons and place this labor in military camps, policed by the army and under the supervision of the army engineers, to be organized for the Herculean task of providing foundation and drainage for the great trunk lines? The need of prisons—great tombs into which erring humanity is thrust to rot—would pass away. A useful work will have been accomplished. Health and vigor would be the lot of the prisoners rather than contamination and disease. Society would gain by saving some part of the $600,000,000 a year which now go, according to one writer, to defray the cost of arrested criminality. The nation would do well to follow the progressive leadership of those States which have already adopted open-air methods in prison reform and are now successfully constructing State roads by prison labor.

A POSITIVE PROGRAMME FOR DISCUSSION.

In short, on the eve of a new age in transportation society needs a quick readjustment to the new inventions. The highways alone now delay. To solve the problem requires intelligent research and accurate information. What railroad president would appropriate money for the improvement of a given stretch of road without exact data in regard to traffic density.

For the purposes of discussion the writer now summarizes several vital points which seem important enough at the present time to become elements of a positive programme. Not as a road expert, but as an economist, not as an engineer, but as a statistician, the writer presents these passing suggestions for the consideration of experts representing, not only the national Government and the States, but also engineers and inventors of patent surfaces.

First, and foremost, we need to know the relative density of traffic upon the important roads of the States, and for this purpose Congress should make a suitable appropriation for a traffic census.

Second, the Office of Good Roads will do well to prepare at once a standard vehicle count blank, inasmuch as, pending Congressional action, much can be accomplished voluntarily by co-operative action.

Third, national appropriations or the proceeds of bond issues should be allotted to the States upon the basis of population, subject to the condition that the State appropriate a given amount.

Fourth, the national funds should be used to develop trunk lines connecting population centers of adjoining States, ending at peripheral belt lines, four to eight miles outside of city sections of congestion.

Fifth, it should be left to cities and States to build out to the belt lines.

Sixth, the national trunk lines should be developed with reference to serving present traffic density.

Seventh, since the interests of through traffic and military uses in times of war are similar, it is desirable to enlist the services of the army engineers and to utilize the possibilities of prison reform through providing open-air work for the prisoners upon the roads.

Eighth, in order to demonstrate the advantages of national trunk lines in times of peace and to emphasize the importance of such trunk lines in time of war, Congress should be urged to hasten the completion of the Lincoln Highway by a large appropriation which would be justified as one important feature of the plans of the War Department for our national defense.

Ninth, agitation for through national highways, such, for instance, as a Washington National Highway to connect the thirteen original colonies, should be encouraged as an efficient aid in enlisting popular support for permanent highways, especially when such routes shall be laid out to serve the routes of present highest traffic density.

Radio-Elements as Indicators in Chemistry and Physics*

By G. Hevesy, Ph.D.

By means of an α-ray electroscope of ordinary sensitiveness it is possible to measure accurately as small a quantity as 10^{-17} grammes of a radio-active substance having a half-value period of one hour. The extraordinary simplicity and at the same time sensitiveness with which it is possible to measure these extremely small quantities of radio-active bodies makes them of the greatest use not only in studying substances in great dilution but also as indicators of physical and chemical processes.

Radio-active indicators may be conveniently divided into two principal groups. To the first group belong those whose use as indicators depends only on their physical properties and not on their chemical properties. Some examples of the use of radio-active indicators of this kind are the following:

It is only necessary to know that the radio-elements composing the active deposits are metals in order to test the formula of Arrhenius connecting the variation of velocity of solution of metals in acids with the temperature. This has been lately carried out by Miss Ramstedt.

It is known from the kinetic theory that the concentration of a solution varies with time, and this problem, which could not be attacked by ordinary methods, has been made experimentally feasible by the use of radio-active bodies as indicators. (Svedberg, Smoluchowski).

The existence of colloidal solutions of radio elements has been lately established by Paneth and Godlewski, and experiments have been undertaken on the formation and precipitation of these colloids using radio-active indicators.

The emanations, the only gaseous radio-elements, have been employed to establish the validity of the gas laws, especially that of Henry's law for extremely small partial pressures. (Bruhat, Boyle).

Fick's Diffusion Law has also been shown to hold accurately for bodies in infinitely small concentration by making use of radio-active substances.

It is often a question of practical interest to the chemist to know how often it is necessary to wash out a pipette or a beaker in order to remove the last trace of the solution it had contained. This problem can be investigated with extreme ease when radio-active indicators are used.

The fact, however, that most radio-elements are throughout in all chemical properties exactly similar to some of the common elements (for instance, radium *D* and thorium *B* are non-separable from lead, thorium *C* and radium *E* from bismuth, etc.) allows these bodies to be used chemically as indicators of the bodies from which they are known to be non-separable. Radium *E* can be used as an indicator for bismuth, radium *D* for lead, etc.

If 1 milligramme of lead is mixed with a quantity of radium *D* which gives 10,000 units of activity in an electroscope, one millionth part of this mixture is easily detectable by the radio-activity of radium *D*. In this way 10^{-6} milligrammes lead is quantitatively determinable.

By this method also the solubility of the difficultly soluble salts of lead, such as the chromate and the sulphide, has been determined. Further, the amount of lead chloride entrained by a precipitate of silver chloride after washing the latter thoroughly with water is measurable.

Experiments on the electrochemical behavior of small quantities of lead and bismuth have been begun. By means of these indicators a study may be made of the electrochemical behavior of these metals for electrode potentials lying below the decomposition voltage, a problem which could not be investigated by any other means.

Of especial use are the indicators for investigating the diffusion and mobility of ions in extremely small concentration, from which results we obtain information concerning the behavior and the hydration of ions in very dilute concentration. Data are already available on the diffusion rate of lead salts down to a normality of 10^{-14}.—*Chemical News.*

* Read before the British Association (Section B), Birmingham Meeting, 1913.

As an experiment, the supervisor of the Beaverhead national forest is stripping the bark from the bases of a number of lodge-pole pine trees at various periods before they are to be cut for telephone poles. This girdling causes the trees to exude resin, and it is desired to find what effect this may have as a preservative treatment for the poles.

View of natural bridge from below.

The bridge has recently been re-enforced by artificial stone piers. It is formed over a ravine of a type common to the region.

In the first forest.

The silicified logs have rolled down from the upper sandstone layer under the influence of wind and water erosion of the rock containing them.

The "Fossil Forest" of Arizona*

Where the American Tourist Should Find Much to Interest Him.

By George P. Merrill, Head Curator of Geology, United States National Museum

The so-called "fossil forest" [1] of Arizona lies some six miles south of Adamana, a station on the Santa Fé Railroad, in Apache County. The expression "so-called" is used for the reason that it is not a forest at all, nor does it bear any resemblance to one, being rather a collection of silicified logs. Could one imagine a collection of saw logs pounded back in a boom and waiting their turn at the mill, and that further this collection had become water-logged, sunken and buried by sediments, he would gain a very fair idea of the conditions which apparently at one time prevailed during the history of the region. There is nothing to indicate that the trees even grew near the locality where the logs are now found. It is apparent rather that they grew at some distant point and were drifted by stream action into eddies after having been reduced to mere trunks or logs through the loss of their leaves and smaller limbs. Here, in various stages of decay, they sank and became buried by the accumulations of sand and gravel and subsequently silicified. Nor are the logs now, with few exceptions, even in the position of their original entombment. The beds in which they once lay have been cut through by erosion and the logs settled, or rolled down to a lower level. In this process they became more broken, and under alternations of blistering heat and freezing cold have been splintered and chipped, oxidized and polished, until the country for an area of many square miles is covered with a bewildering array of broken trunks and fragments of agate and jasper, varying from nearly colorless through yellow and red to the most brilliant carnelian. The few logs which remain in the position of their original entombment are widely scattered and the one best known to the tourist is that forming the so-called "natural bridge," where an enormous log has been undermined by the action of temporary streams and remains supported at both ends spanning a chasm of nearly fifty feet in width and twenty or more in depth.

It is apparent that there were at least four eddies in which the logs accumulated in the area now comprised within the reservation known as the Petrified Forest National Monument of Arizona. The first lies some six miles south of Adamana. This area includes the natural bridge already referred to, and a considerable collection of broken trunks which, while interesting and instructive, cannot compare in point of beauty or size with the second, third, and Rainbow forests further to the south and southwest. Both the second and third have suffered less through erosion than the first, and the logs are less broken, and it is here that one gains the best impression of the enormous dimensions of these silicified monsters. Trunks occur of all sizes up to 5 feet or more in diameter, and 60 or 80 or even 100 feet in length. Of all the deposits, that known as the Rainbow Forest is the most fascinating on account of the richness of the colors, although from a geological standpoint it is a wreck. Few if any of the trees occupy their original position of entombment, but are all tumbled about in a confused, chaotic manner, in the numerous gulches and ravines which result from the spasmodic periods of erosion characteristic of arid regions.

It is to be regretted that the average tourist, who devotes season after season to European travel, does not feel that he can devote more than a portion of a single day to the investigation of these wonderful deposits of his own country. This necessarily limits him to the first, or possibly to the first and second forests. One should devote at least two days to them, passing the first day through the first and second forests and arriving at the third in season to camp at the one water hole within the entire area. The forenoon of the second day can well be given up to exploring the third and Rainbow forests, and the afternoon to the return to Adamana. Such a trip involves no hardship. Camping at the altitude of 5,000 feet in the dry atmosphere is simply exhilarating, and the supply of food and water needed can readily be carried with the outfit which is furnished by the superintendent at Adamana.

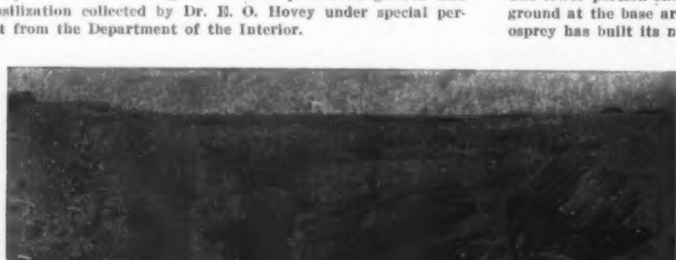
The geology of this area was first worked out in detail by the late Prof. Lester F. Ward, then connected with the United States Geological Survey. He described the region as consisting of the ruins of a former plain having

Spectacular effect of erosion in the first forest.

The lower portion shows clays of many colors and on the ground at the base are broken logs of petrified wood. An osprey has built its nest on the pinnacle of sandstone.

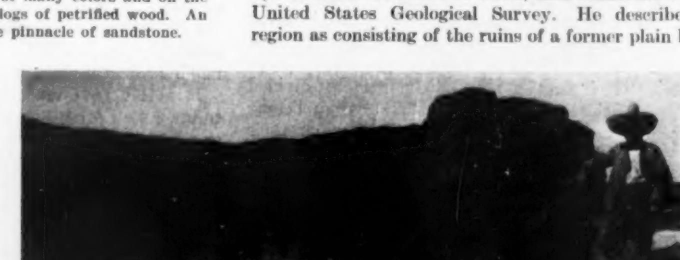
* Reproduced from the American Museum *Journal*.

[1] The area of the Petrified Forest is well represented in a map issued by the United States Geological Survey. The map published in December, 1912, is the result of a survey made two years previously, and shows the location and topography of the six separate forests. The trees are perhaps millions of years old, and consist to-day of many-colored agate, an exceedingly hard and tough stone. Visitors to the American Museum can see many interesting specimens from the Petrified Forest. In the gem room are several particularly fine polished slabs of agatized wood from near Adamana, and in the mineral collection is a two-foot section of agatized log from the same region. In the corridor on the ground floor leading to the building stone collection is a considerable series of specimens illustrating the several phases of growth and fossilization collected by Dr. E. O. Hovey under special permit from the Department of the Interior.



Scene about eight miles east of Adamana.

The ground is covered with chips broken off from the logs by Indians in making arrow points. Hammers of agatized wood were used in chipping the logs.



Only a few of the fossil trees remain intact.

The greater number cover the ground in a bewildering array of broken trunks and fragments of agate and of jasper.

Natural bridge, seen from above.

The log best known to the tourist is the one in the first forest, forming the so-called "natural bridge." This log remains in the position of its original entombment, but has been undermined by water until it is supported at the two ends only over a chasm fifty feet wide and twenty feet deep.

General view in the third forest.

The fossil forest of Arizona shows a natural division into separate so-called "forests." The photograph presents a general view in the third forest quite typical of the whole region, which has suffered less from erosion than the first, the logs are less broken, and here one gains the best impression of their dimensions.

an altitude above sea level of something like 5,700 feet. This has now undergone erosion to a maximum depth of nearly 700 feet and is cut into innumerable ridges, buttes, and small mesas, with valleys, gorges and gulches between. The rock formations consist of nearly horizontal, alternating beds of purple, white and bluish marls, sandstones and shales, giving a lively and pleasing effect, such as is characteristic of so many of the landscapes of the State. The beds in which the logs were entombed were deposited at the bottom of a Mesozoic sea, where they remained until Tertiary times when the entire country was raised from 5,000 to 6,000 feet above sea level. The logs throughout the area belong to a cone-bearing tree, of a single species, described by Dr. F. H. Knowlton of the United States Geological Survey under the name of *Araucarioxylon arozonicum*, a tree no longer found in the northern hemisphere, its nearest representative being a small cultivated form known as the Norfolk Island pine.

As to how the trunks became petrified or silicified we are still somewhat in the dark. Silica is ordinarily one of the most insoluble substances, but nevertheless readily soluble in an alkaline solution—that is, one containing soda or potash. It is probable that the solutions permeating through these beds were of this nature and as the logs gradually decayed their organic matter was replaced, molecule by molecule, by silica. The wood is therefore not "turned to stone," but has simply been replaced by mineral matter, mainly silica. The brilliant red and other colors are due to the small amounts of iron and manganese deposited together with the silica, and superoxidation as the trunks are exposed to the air. The more brilliant colors are therefore to be found in the small chips lying on or near the surface.

Prior to 1906 these forests were on Government and railroad lands and subject to the vandalism of curiosity seekers and those commercially inclined. At one time a considerable industry was carried on in cut and polished sections of the sounder and more highly colored varieties and visitors to the numerous expositions of late years will probably remember the striking examples shown by a firm with headquarters at Sioux Falls, South Dakota. Fortunately, the matter attracted the attention of public-spirited men and in 1895 the territorial legislature of Arizona memorialized Congress, calling attention to the region and asking that the area be set aside as a national park. This was done after the investigation by the Land Office and the Geological Survey, and a proclamation by President Roosevelt issued June 8th, 1906, set it aside permanently as a public wonderland and playground. Subsequently, in 1911, the area was resurveyed and reduced in size and a new proclamation issued by President Taft.

In order to preserve the forest indefinitely visitors are prohibited from breaking or injuring the logs in any way, although permitted to carry away a few pounds of chips picked up from areas set aside for the purpose.

Cab Signals on Locomotives*

The idea of giving a driver an intimation in the locomotive cab of the condition of the outdoor signals is almost as old as the signals themselves, while automatic train control is nearly as ancient, a patent specification for the latter having been taken out so far back as the year 1856. The provision of cab signals presents fewer difficulties than does the use of automatic train control, i. e., the pulling up of a train automatically and independently of the driver, and the following remarks deal more particularly with the easier scheme, although train control will also be noticed.

WEAKNESS OF EARLY PLANS.

Nearly all the earlier designs put forward for giving cab signals consisted of an obstruction between the rails, or outside one of them, together with a corresponding lever, trip, trigger, or other obstruction on the engine. Generally the former was raised when the signal was "on" and so hit the attachment on the engine. This form was objectionable in that the track apparatus, being coupled to the signal, added weight to the latter, and it also interfered with the adjustment of the signal wire, so causing ambiguous signals neither fully "on" or fully "off" to be shown. The weakness that soon became apparent was that when the track equipment or the engine equipment was struck at high speed one or the other was broken. The signalman might not become aware of the former, and consequently subsequent trains would not get the indication, and so the drivers might assume that the signal was "clear." Or the driver might not know that his equipment was gone, and would not get adverse indications at the remaining signals he passed, because there was no corresponding obstruction to repeat a "clear" signal when such was given. Little consideration, too, was paid by inventors to the vital point that all failures should result in danger signals being given.

It was Mr. W. S. Boult who introduced the first successful cab signal, and this was tried on the M. S. and L. (now Great Central) Railway. Induction was used to give the "on" and "off" positions of distant signals and of home and starting signals, and at junctions the direction for which the road was "set" was also shown. The experiments, although successful, did not commend themselves to the companies, as Mr. Boult was then, in the early nineties, before his time.

AUDIBLE CAB SIGNALS.

In 1905 some practical railwaymen on the Great Western Railway got nearer to the perfected device than any who had gone before. Their arrangement consisted of a ramp at the distant signal which, as a shoe suspended from the locomotive passed over it, caused the shoe to rise. The rising of the shoe opened the engine whistle. The ramp was, however, connected by an aerial electric wire to a battery in the signal-box, and if the distant signal was "off" the battery was joined up to the ramp so that the latter was, in a sense, electrified. The shoe picked up the current which passed to a relay that controlled the whistle and prevented it from sounding. Another relay joined up a local battery also that caused a bell to ring.

The sequence then was that if the line was not clear the ramp was not electrified and the whistle was opened. If the line was clear the ramp was electrified and so the whistle remained closed and the bell rang instead. It therefore required a current to stop the whistle from sounding. Any failure would consequently lead to a danger signal being given. That the ramp was fixed, and not coupled mechanically to the signal, was a good feature.

This system was tried for two years on the Henley branch, where one point in particular was tested. Trains regularly ran over the ramps at speeds of over 60 miles an hour. Then, at the beginning of 1907, it was installed on the Fairford branch, a single line 22 miles in length. Here an important further step was taken, as the distant signals were dispensed with. The drivers got the "distant" indication by means of the ramp which, in this case, was electrified by means of a switch attached to what had been the distant signal lever in the signal-box, which lever was interlocked so that it could not be pulled to "clear" unless the stop signals were "off."

INSTALLATION ON THE GREAT WESTERN RAILWAY.

Before giving some account of what has been done on the Great Western, some figures as to the operations on the Fairford branch may be instructive. The average number of signal operations a year is 5,650. For the period of 1¾ years from January, 1908, to September, 1909, there were 53 failures which were classified under five headings thus: Bell ("clear"), instead of whistle ("danger"), nil; neither bell nor whistle, 4; both bell and whistle, 10; whistle instead of bell, 38; whistle independently of ramp, 1. It will thus be seen that not once was a "clear" signal given instead of a "danger." The results under the second and third headings would lead to "danger" being accepted. The four cases of neither bell nor whistle should have been bell indications and not whistles.

The results on the Fairford branch being so satisfactory the company began to install the system on the main line between Paddington and Reading, and now the whole of the first 36 miles out of London, all of which have four lines of way, have the audible signal equipment. There are approximately 200 ramps, but, for the present, no distant signals have been dispensed with. The same good reports as to failures are received; as yet there have been no cases of false "clear" signals being given, and narly all the instances where the whistle has been opened instead of the bell rung have been due to the fact that the ramps are electrified by the action of the distant signals themselves, and therefore, if a signal arm does not fall to the full "clear" position, the circuit to the ramp is not completed and therefore the necessary electrical power to restrain the whistle does not pass into the engine equipment.

It must also be remarked that the Great Western Railway has gone further than simply providing cab signals. It has between 50 and 60 engines fitted with cab signals, of which one half have the further equipment of train control. The remainder are being so fitted also, and it is in this direction and not on extending the system that the company is spending the money voted for the installation. It is also a point that deserves attention that at first the locomotive authorities on the Great Western Railway objected to the automatic application of the brake; but now that it has been tried their objections have been converted into strong approval.

PROGRESS IN OTHER DIRECTIONS.

The North-Eastern Company can also give a good account of itself in this matter. For many years it has had a cab signal, which, however, is mechanical and only repeats the danger indications. Some few years ago, however, Mr. Vincent L. Raven, the chief mechanical engineer, turned his attention to electrical cab signals, and a system was subsequently installed between Newcastle and Durham which gives the "on" and "off" position of all the running signals and the direction at junctions, also an intermediate warning between the distant and home signals. Then, in August, 1911, the system was installed along the whole length of the Richmond branch of the same company. There are 36 engines equipped with the apparatus, and it is quite expected that further extensions will shortly be ordered.

It is not generally known that the Midland Company has had for some years, and still has, its Wirksworth branch and a couple of engines equipped with the audible system as used on the Great Western. No other British company has any cab signal or train control in regular work, although several have made experiments therewith.

* Reproduced from the Engineering Supplement of the *London Times*.

High-Speed Rotary Machines*

Leblanc's Researches and Inventions

By L. Lecornu

The constructors of motors are continually endeavoring to increase the rotational velocity of the principal shaft. This increase in velocity diminishes bulk and weight and often simplifies transmission. In steam engines it also diminishes condensation and its attendant evils. In piston engines, unfortunately, increase in speed augments the effect of the inertia of reciprocating parts and hence makes equilibration more difficult. This disadvantage is much less serious in rotary engines where the force of inertia is practically a centrifugal force of constant magnitude. This is one reason for the success of rotary motors in aviation.

In this respect steam turbines are greatly superior to engines with fixed cylinders. Reaction turbines, which employ partially expanded steam and rotate with comparative slowness, are easily balanced, and need not be considered here. Action turbines, which employ steam expanded to atmospheric pressure, rotate very swiftly, for they operate most economically when their blades move about half as rapidly as the jet of steam. Now, steam from a boiler at 10 atmospheres pressure attains a speed of 1 kilometer per second at the mouth of the twyers. Hence the blades must travel 500 meters per second, so that a turbine of 20 centimeters (8 inches) radius must make 400 revolutions per second. In such conditions each pound mass at the periphery experiences a centrifugal force of 63 tons weight.

To resist such forces the turbine must be made of very strong material in accordance with correct structural principles, and its axis must be a natural axis of rotation and must pass, as nearly as possible, through the center of gravity.

The Swedish engineer De Laval, recently deceased, who invented the action turbine, was long baffled by the impossibility of satisfying these conditions exactly. He increased the size of his shafts, but they continued to break until he conceived the idea of making them flexible. A turbine with a flexible shaft behaves very much like a top. Its axis, though it possesses the dynamic stability due to its great velocity, is subject to small oscillations which do no harm unless they are checked, when they may produce disastrous effects. In short, the shaft bends, instead of breaking, like the reed in the fable.

These small oscillations, however, may ultimately alter the structure of the metal. It is better, therefore, to employ a rigid shaft, mounted in elastic and easily renewed bearings. This has been done by M. Maurice Leblanc, whose remarkable researches we propose to describe. The Leblanc bearing (Fig. 1) is supported by three radially arranged spiral springs $R_1R_2R_3$ provided with screws $S_1S_2S_3$, by which their tension can be regulated and the bearing can be accurately centered. Increasing the tension of the springs diminishes their natural period of vibration T, which should be made shorter than the time of rotation T' of the shaft, in order to eliminate the possibility of impressing on the shaft impulses synchronous with its small oscillations due to imperfect centering, for such rhythmical impulses might greatly increase the oscillation.

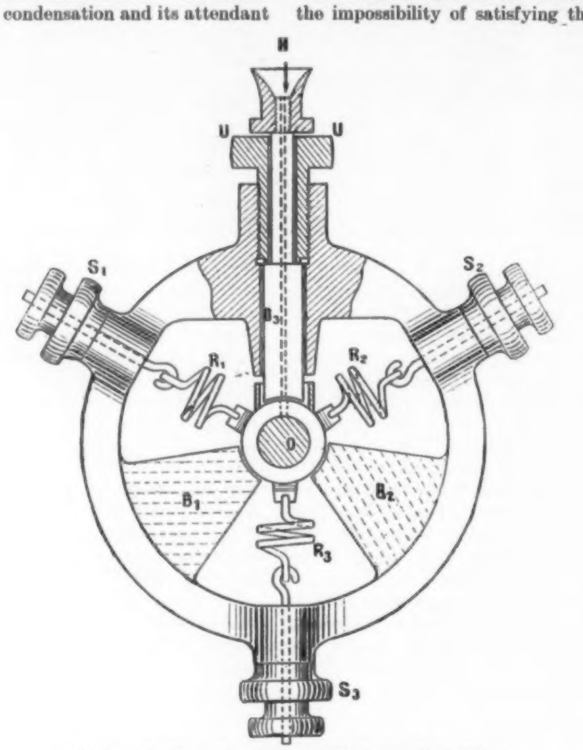


Fig. 1.—Leblanc bearing for high-speed turbines.
O, shaft of turbine; $R_1R_2R_3$, springs; $S_1S_2S_3$, tension screws; $B_1B_2B_3$, guide blocks; U, screw operating movable block; H, oil-cup.

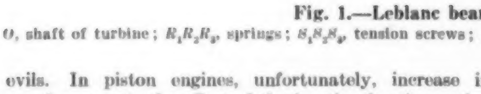


Fig. 2. Fig. 3.
Figs. 2 and 3.—Deformation of shaft with and without fixed bearings.

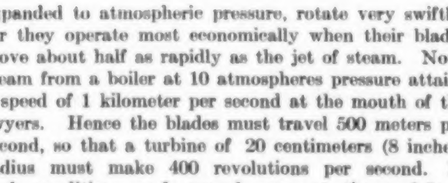


Fig. 4. Fig. 5.
Figs. 4 and 5.—Diagrams illustrating the theory of the Leblanc stabilizer.

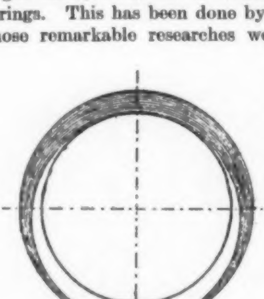


Fig. 6.—Mercury channel of Leblanc stabilizer.

But the springs, though strongly stretched, must be very flexible, for the following reason: When one end of a spring is fixed and the other end is attached to a heavy movable mass M, the period of vibration T'' of the spring thus loaded (which is very different from the natural period T of the unlocked spring) is proportional to the square root of the quotient obtained by dividing the mass M by the coefficient of elasticity of the spring. In the present case the mass M is represented by the rotating turbine and shaft. By employing very flexible springs the period of vibration T'' can be made greater than the time of rotation T' of the turbine. Every possibility of dangerous synchronism is removed, therefore, by making the time of rotation T' much longer than the period T of the unloaded spring, and yet much shorter than the period T'' of the loaded spring.

In starting, however, the speed of rotation increases gradually from zero to its normal working value, so that at one instant T' is equal to T. The production of violent oscillations at this moment is prevented by the guide blocks $B_1B_2B_3$ (Fig. 1) which surround the bearing. In the normal running of the turbine these blocks are separated from the bearing by intervals of 1/12 to 1/8 inch, which suffice for the action of the springs, but before starting (and also before stopping) the machine, the movable block B_3 is lowered by means of the screw U, forcing the bearing down on the fixed blocks B_1B_2 and holding it motionless until the critical speed has been passed, when the screw is loosened. The screw and blades might be operated automatically by a speed indicator attached to the shaft, as M. Leblanc suggests.

The periods T and T'' are not the only periods of vibration that must differ from the time of rotation T'. The rotor of the turbine, like other solid bodies, is susceptible of various vibrations whose periods depend on its size, form and structure. The coincidence of any of these periods with the time of rotation might produce disastrous results. Regarded from this point of view the Leblanc system presents a marked advantage. When the ends of the rotor turn in fixed bearings the axis of figure may be bent by centrifugal force into a curve lying entirely on one side of the axis of rotation (Fig. 2). The suppression of rigid supports shifts this curve so that its middle part is on one side and its ends are on the other side of the axis of rotation (Fig. 4).

It is not sufficient to give the axis of the rotor a certain degree of freedom. It is necessary, also, to balance the mass around its axis as accurately as possible in order to minimize heating of the bearings and wear of the springs. It is impossible to construct a perfectly balanced rotor, but Leblanc has devised an automatic stabilizer which automatically corrects small structural defects of this sort. In order to explain the principle of the stabilizer let us consider a disk of any form D (Fig. 4) rotating in its own plane about a point very near its center of gravity G, and let us suppose that a leaden ball is free to move in a channel which forms a circle around a point O of the disk. Centrifugal force will drive the ball to the point B, as distant as possible from the center of rotation G. In this position the mass of the ball will displace the center of gravity of the system to a point G', between G and B, thus increasing the distance of the center of

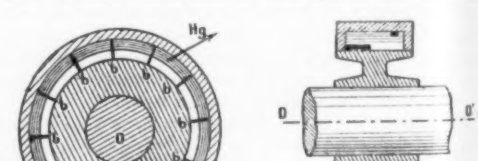


Fig. 7.—Transverse and axial sections of simple Leblanc stabilizer. OO', axis; K, mercury channel; bb, radial partitions; cd, apertures in partitions; Hg, mercury.

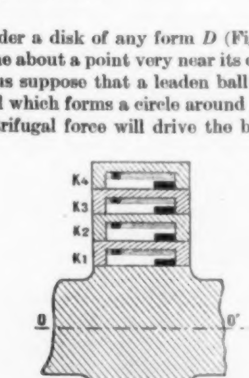


Fig. 8.—Axial section of multiple Leblanc stabilizer. OO', axis; $K_1K_2K_4$, mercury channels.

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the *Revue Generale des Sciences.*

gravity from the axis of rotation and aggravating the defect of equilibrium.

If the disk, however, has no fixed point, it will rotate about the common center of gravity G', and the centrifugal force will tend to drive the ball as far as possible from that point. Now, for any position B (Fig. 5) of the ball the common center of gravity G' lies on the line $G\,B$, which joins the centers of gravity of the disk and the ball, and the distance $G'\,B$ between the ball and the common center of gravity is equal to $G\,B \times \frac{M}{M+m}$ where M denotes the mass of the disk and m denotes the mass of the ball. Hence $G'\,B$ will attain its maximum value simultaneously with $G\,B$; i. e., when the ball is at B_1, on the prolongation of $G\,O$. In these conditions the common center of gravity is at G'_1 at a distance from G equal to $G\,B_1 \times \frac{m}{M+m}$. Hence, unless $\frac{m}{M+m}$ is too large, the effect of the ball is to bring the center of gravity of the system nearer to the point O, or nearer to the axis of figure if the point O is taken on that axis.

Instead of a leaden ball Lablanc employs mercury, partially filling a channel which forms a circle around the axis of the rotor (Fig. 6). The movements of the mercury are checked and controlled by radial partitions b (Fig. 7), having at their outer edges perforations c for the passage of the mercury, and at their inner edges perforations d for the passage of the air or the viscous liquid which fills the remainder of the channel. Usually each stabilizer is composed of a number of concentric channels $K_1K_2K_3$ (Fig. 8).

By attaching one of these stabilizers to each end of the rotor shaft the natural axis of rotation can be kept so near the axis of figure that the movements of the latter are imperceptible. Hence the clearance between the rotor and the stator may be made very small. This is of little importance in action turbines, for the jets of steam, being nearly at atmospheric pressure, have little tendency to escape even when the clearance is large, but it is very advantageous in some other rapidly rotating machines.

The employment of high velocities has enabled M. Leblanc to construct rotary compressors of great power and small size. In order to eliminate the deforming effects of centrifugal force the blades of these compressors are plane and are placed radially. At first the blades were made of ramie fiber saturated and varnished with acetate of cellulose and were finished automatically by the friction of their ends against the stator. Subsequently the inventor, having succeeded in obtaining metal of sufficient strength, adopted metal blades less than 1/25 inch thick at the heel attached to the axis and diminishing in thickness toward the periphery. The great centrifugal force developed gives these very thin blades ample rigidity.

The application of the Leblanc system to dynamos has not yet been worked out practically. The inventor suggests the employment of a rotor with collectors and having only two poles in order not to multiply the variations of flux uselessly; winding of the Gramme type in which the connecting wires are supported by the sheet iron ring; conductors of tinned aluminium. The principal difficulty is to obtain sheet iron in which mechanical strength and high electrical resistance are associated with very small hysteresis. Tempered steel cannot be used because the magnetic alternations would soon destroy temper and lower its limit of elasticity. The best results have been obtained with a steel containing 1.87 per cent of silicon, having an elastic limit of 47 kilogrammes per square millimeter, and breaking under a load of 69 kilogrammes, with an elongation of 25 per cent.

The rapidly running dynamo would present the advantage that it could be coupled directly to an action turbine, and its small size would make it very valuable in some situations, especially on shipboard.

The adoption of the Leblanc system may ultimately produce the greatly desired internal combustion turbine, using gas or petroleum oils as fuel. Here, however, formidable difficulties are encountered. According to M. Leblanc such a turbine, to be efficient, should have a tangential velocity of 800 meters per second, and no known material can withstand the effects of so rapid a rotation. Probably it would be necessary to employ a metal which is really homogeneous, and not, like known steels, composed of particles of iron cemented together. Leblanc suggests that steel might be made homogeneous by fusion in the electric arc under high pressure.

The dynamical functions of flexible and flexibly suspended axes are exceedingly complex, but Leblanc has elaborated an ingenious mathematical theory of their action, and has also constructed practically satisfactory suspensions and stabilizers. Hence the speed of a rotor is limited only by the strength of its material. We now possess nickel steels and chrome steels, which have an elastic limit of more than 160 kilogrammes, and can safely sustain a working load of 40 kilogrammes per square millimeter. A properly designed rotor made of such materials can be run at a tangential velocity of 460 meters (1,509 feet) per second.

German War Aeroplanes

Americans pay but little attention to the developments in aerial navigation made by Germany, particularly in the construction of military flying machines. Commenting on the German air craft works (*Deutsche Flugzeug Werke*) the London *Daily Telegraph* remarks:

"Of the strength of the German aviation establishment there is no longer any question; judging from reliable reports, it is now even greatly superior to that of France. In one center only—that of Doeberitz—there are actually 200 war machines ready for instant mobilization and prepared in every respect to take the air at once. But it is the type of machine and its qualities that are of interest, for these in a measure reflect the policy of the German aerial force, and they may be studied with advantage.

"In the first place, it is evident that speed in this case only forms a secondary consideration. Reliability and endurance are the principal results aimed at. With few exceptions German and Austrian aeroplanes have their wings swept back; in other words, seen in plan view, they present the shape of a wedge, with the point forward in the direction of flight. This characteristic feature has earned them the title of 'Arrow' biplanes and 'dove' monoplanes. Further, the wing-tips are usually uptilted, a feature which in conjunction with the wedge shape produces some degree of automatic stability while leaving full control to the pilot. In this respect the arrangement differs from that of the Dunne, where stability is inherent, and the pilot can exercise but little control. The intention is simply to relieve the pilot from the continuous strain imposed upon him in long cross-country flights. That it is successful in this respect has been proved time and again during the past few months by the remarkable long-distance flights made by various German pilots, of which the wonderful performance of Stoeffler, who covered 1,290 miles in twenty-four hours, may serve as an example. Save for the maneuvers of steering, the pilot of such an aeroplane has little need to bother about controlling his machine, with the result, first, that the physical and mental strain to which he is subjected, and only those who have flown continuously for several hours at a stretch can realize the intensity of this, is practically eliminated, and, secondly, that he is thereby free to devote himself to other duties, such as that of observation.

"Let us take the D.F.W., which embodies both the virtues and the faults of the average German type, as an example. The writer recently had an opportunity of testing its behavior in flight. Although the afternoon was calm, it was nevertheless possible to gain a good notion of the remarkable stability of the machine. Since it was provided with dual control, one could follow the controlling movements of the pilot accurately. Apart from the use of the elevator for rising and descending, and a slight movement of the rudder in turning, no control was ever exercised, and, according to Roempler, the pilot, the ailerons are scarcely ever operated even in gusty winds. These ailerons form the up-tilted wing-tips, for they are placed at a negative angle and cannot be depressed beyond the horizontal. The system is one which in several respects, apart altogether from the question of stability, is to be preferred to the ordinary ailerons in general use.

"Like the majority of German machines, the D.F.W. is unduly heavy, for it weighs no less than 1,500 pounds empty. But this great weight is compensated by its structural strength. The fuselage and the chassis are made of heavy steel tubing; in more recent models the wing spars and struts are also of steel, the only wooden parts being the wing ribs. The very first glance reveals the exceptional strength of the whole structure. The German designers, following the opinion of military authorities, in fact, sacrifice speed and quick climbing power to reliability, arguing that a slow machine capable of withstanding heavy landings, and therefore of remaining in continuous use, is preferable to a fast machine which is almost certain to be destroyed in the first rough landing. Here we find what may be described as the French and German schools in direct opposition. The aeroplane designer in France designs his machine for the crack pilot; the German designer produces an aeroplane possessing flying qualities which may be inferior to those of the former, but which is nevertheless a machine which can be flown safely and effectively by the average and even the mediocre pilot. On the whole, the latter method appears to be the sounder so far as military machines are concerned, for first-class pilots are few and far between.

"But the D.F.W. possesses other qualities which are highly valuable from a military point of view. The pilot is seated exceptionally far back in the fuselage; the observer's seat is about the trailing edge of the planes, so that he has a clear view vertically downward. In this respect this aeroplane is far and away superior to any British biplane of the tractor type. If the speed is comparatively low—with full load it scarcely exceeds sixty miles an hour—and if the rate of climbing is not particularly fast, the weight-carrying capabilities of this aeroplane are remarkable. It is equipped, as a standard fitting, with a fifty-gallon tank, sufficient for twelve hours' fuel. This, together with pilot and passenger, represents a useful load of some 800 pounds. According to the German regulations, a military aeroplane before acceptance must undergo an hour's flight with seven hours' fuel, pilot and passenger, and leave the ground and stop again after alighting within seventy yards. These conditions are arduous enough, and it is evident that if all the present German military aeroplanes fulfill these conditions, the German army possesses a very powerful weapon in its aviation corps.

"But, all said and done, this aeroplane and the majority of other German machines owe the greater part of their efficiency to their wonderful motors. The 100 horse-power Mercedes with which D.F.W. is fitted is probably the nearest approach to the perfect stationary aeroplane engine that is possible to-day. It is a six-cylinder engine of the ordinary type familiar in motor-car practice, with which it is identical except for the great saving in weight. At its maximum speed of 1,400 revolutions a minute it develops 114 horse-power, and, including the radiator, weighs no more than 375 pounds. Even more remarkable is its low fuel consumption. It requires practically no oil—the quantity contained in the sump suffices for a flight of average duration, and only consumes three pints of gasoline an hour. Among the other advantages of the upright stationary engine is the fact that it can be throttled down to very low speeds. The engine under consideration is also provided with a self-starter, a small dynamo worked by the pilot, which enables it to be started at any time from the pilot's seat. Perhaps the most noteworthy feature of this engine is its reliability, wherein it closely approaches the ordinary motor-car engine. It approximates, in fact, to standard practice throughout."

A New Soap Material

Settlers in western Kansas are cutting and marketing soap weed, or Spanish bayonet, to supply the demands of soap manufacturers, according to a report recently received from officers of the Kansas national forest. There are various plants in the southwest locally known as soap weed, called amole by the Mexicans, but the one gathered by the Kansas farmers, technically known as *Yucca bacata*, a species with exceptionally large fruits, is most used. The soap manufacturers, however, utilize the tops or the roots. Manufacturers are paying $8 a ton for the plant at the railway stations, while the estimated cost of cutting, drying, baling and hauling ranges from $5 to $6, depending upon the distance to the railroad. Since a man can ordinarily get out a ton a day, the gathering of the soap weed affords an opportunity to secure a fair day's wages at a time when other ranch activities are not pressing. After cutting, the soap weed is allowed to dry from 60 to 90 days and then is baled up in the ordinary broom-corn baling machine.

For a long time this weed has been made into a soapy decoction which the Indian and Mexican women have used, particularly for washing their hair, for which purpose it is considered especially suited, since it contains no alkali. Present-day soap manufacturers use it for toilet and wool soaps. Its qualities have been known for a long time, but the harvesting of soap weed is just now becoming commercially important.

The industry is now operating on lands adjacent to the Kansas national forest, and it is expected that the demand will soon spread to that forest, some portions of which bear an abundant supply of the plant. There is a plentiful supply of it throughout southern Colorado, Arizona, New Mexico and Texas.

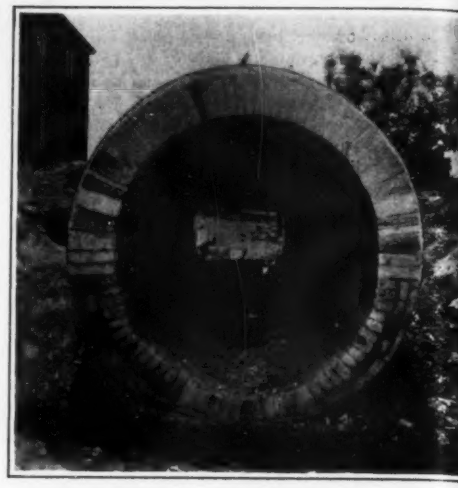
Forest officers have considered this weed a nuisance, since it is the nature of the plant to spread over extensive areas and kill off other vegetation. It is particularly a pest on stock ranges. In line with its policy of range improvement, the Government is anxious to rid the forage areas of all such injurious plants, and it is the hope of the forest officers that the commercial demand for soap weed will soon reach such proportions that it will not only take an otherwise useless product, but also will eradicate it from areas which could be utilized to better advantage for the supplying of forage to cattle and sheep.

Canada has 23,000,000 acres in timber reserves, as compared with 187,000,000 acres in the national forests of the United States.

"Combustion of coal" testing apparatus, showing gas and air connections to combustion chamber.

Improvised Mine Fires on an Experimental Scale

An underground Fire Chamber for Experiments on Spontaneous Combustion and Mine Fires



Cross-section of "combustion of coal" apparatus, showing the method of constructing brick lining.

THE Bureau of Mines has recently installed, at its Pittsburgh experiment station, an underground chamber, or furnace, in which to carry on experiments relating to mine fires and spontaneous combustion as occurring in mines.

A section of steel tube cylindrical in shape, 6½ feet in diameter and 27 feet long, was laid on its side in a deep trench, and after lining this shell with fire brick and mineral wool, and stopping the ends with 13-inch brick walls, it was covered with 2 feet of earth. The chamber was constructed so as to be as nearly air-tight as possible, and in such manner as to retain to the greatest degree practicable any heat generated within its walls.

At one end, a motor-driven fan will blow in air at a rate which can be accurately measured, and at the other, a stack is provided which can be opened or closed as desired. Through the top of the chamber, at frequent intervals, pass small pipes for withdrawing samples of air or gases, and for inserting pyrometers for temperature measurement in the interior.

The chamber will hold 6 to 8 tons of coal when one third full. It is expected that different kinds of coal, or of waste material from mines, will be placed in the chamber and a study made of spontaneous development of heat in them under various conditions. After an active fire has been started in the chamber, either by this means or artificially, experiments will be made on controlling the fire by reducing the air supply or by sealing it off entirely. The progressive changes in composition of the fire gases, or of the air surrounding the coal, will be followed and temperature measurements made, in an endeavor to apply the data thus obtained to solving practical problems in the treatment of fires.

Investigations have been made in other countries, and to some extent also in this country, of the gases produced in actual cases of mine fires both before and after sealing off a burning area. The Bureau is now making, however, probably the first attempt to investigate such problems in an experimental apparatus which permits careful control of conditions and yet is on a scale nearly commensurate with mining operations. These investigations are being carried on by Horace C. Porter, chemist of the Bureau of Mines.

Uses for Waste Sawdust

SWEEPING compounds are largely composed of sawdust and silicious material, together with some such binding medium as rosin, tar, or some of the crude oils in the market, says the *Woodworker*. The idea is to impregnate the sawdust with some cheap mineral oils that oxidize but little and keep moist for a long time. Aqueous oils are also considerably used, as they mix readily with water. If too little fluid or oil is used, the sawdust will not be given its highest absorbent efficiency, and if too much is used, oil or flat stains are likely to show on the swept surface.

The following formula gives the ingredients and processes necessary for making a sweeping compound: Melt 2 ounces of paraffin wax in 2 quarts of paraffin oil over a water bath; add 6 ounces of coarse salt, 5 pounds of white sand, 10 pounds of pine sawdust, and 1 ounce of oil of eucalyptus—the last is merely to give a pleasant odor. Mix thoroughly and knead until every particle shows moisture. Heap and leave over night so the oil may soak into the fiber and spread evenly. This formula would probably prove much more profitable if a cheaper oil were substituted for the paraffin, and it is merely given to show proportions. Such a compound is packed in boxes and retailed by grocers at 10 cents for the 1-pound size and 25 cents for 3-pound packages.

Sawdust is being used to a considerable and growing extent in many machine shops as a substitute for cotton waste. It has been used with cement to make a concrete floor into which nails may be driven. A floor of this kind in the public library of Springfield, Mass., is said to be a success. Reports from Hamburg, Germany, state that sawdust mixed with magnesium chloride is used there extensively for floors in the larger commercial buildings, where it is said to be popular because of its cheapness and partly fireproof qualities.—*Engineering Digest*.

Side view of "combustion of coal" apparatus.

Fiords and Other Inlets of the Sea*

To What Agencies Do They Owe Their Origin?

By Prof. T. G. Bonney

Like an experienced teacher, Prof. Gregory begins his book on "The Nature and Origin of Fiords" by a definition of its subject. Fiord is a Scandinavian word, and fiords are common on a large part of the coast of Norway, but the term is often used vaguely, and sometimes, as we shall see, with unjustifiable restrictions. With him it denotes an inlet of the sea, bounded by lofty and steep opposing walls; piercing far into the land, and consisting of long straight reaches, which turn and receive their tributaries at sharp angles. Thus, though a fiord is a sea-drowned valley, not all such valleys can be called fiords. It has been carved, as the definition suggests, in a plateau more or less elevated, which consists of hard rocks, and it is named a fiord when this plateau is low, the difference betwen the two being obviously varietal rather than specific, and a comparatively slight elevation, on such a coast as that of Norway, might show the one to end in the other. It remains narrow to its seaward end, thus differing from an ordinary estuary, which widens in that direction, so that waves may have helped in forming it, while they have done little for the fiord; and when one of the former has an irregular outline, and is bordered by bold rugged hills, it is designated a ria, from a Spanish name. Fiords are frequent in the northern and southern portions of the globe, and practically absent from the more tropical regions; they also often bear marked signs of glaciation. That, however, does not prove them to have been excavated by ice, or justify refusing to give the name fiord to a submerged valley with the other qualifications, for any such limitation is importing a hypothesis into a definition. This geographical distribution, however, is a fact, and Prof. Gregory attributes it to terrestrial conditions, which make oscillations in level more frequent in the higher than in the lower latitudes.

From this preliminary discussion he proceeds to describe concisely the fiords in the several parts of the globe, in order to ascertain, by inductive study of their phenomena, by what agencies they may have been formed. Beginning with those of Norway, the home of the name, he points out the more important features in each, its relation to the neighboring district, its outline and dimensions, with details, whenever obtainable, of its subaqueous contour. The Sogne fiord in Norway, one of the most accessible to English visitors, exhibits the characteristic features of such an inlet, especially in its upper branches, not less distinctively than that grand example, Milford Sound, in New Zealand (Fig. 1). The sides, to summarize Prof. Gregory's description, are high and steep, not broken by deep gullies, so that the streams rising on the uplands frequently descend as water-falls over the walls instead of as cataracts hidden in deep gullies. We may therefore conclude that these cascades are comparatively modern—more modern, for instance, than in the Alps, where the other habit is the more common. Those side-walls also are often subparallel, so that the fiords for considerable distances are uniform in width, their valleys also taking a straight course. The most typical Norway fiords are surprisingly deep, the maximum in the Sogne fiord being almost 4,000 feet, and the walls descend for a long way beneath the surface of the water with as steep a slope as they have for some 2,000 feet above it. Thus a cross-section on their floors is trough-like, but the longitudinal one is a concave curve. In some cases the fiord bed rises and falls more than once in this direction, as in some Alpine and Scotch lakes, but in most cases, though not in all, the fiord has an outer (submerged) rim, sometimes narrow, sometimes comparatively wide, which prevents a free influx of the deeper ocean water. This, though it may sometimes consist of moraine deposited by a retreating glacier, or of ordinary detritus, like the bar at the mouth of an estuary, must often be, as Prof. Gregory explains, a true rock barrier. This last characteristic, together with their ice-worn rocks, the truncation of spurs from the mountain on either side, and their geographical distribution, have caused some geologists not only to attribute fiords to glacier erosion, but also to refuse the name to any similar submerged valley which could not have been formed in this way.

But besides the general objection to this limitation, which has already been mentioned, the Dalmatian coast can show fiords as characteristic as those of Norway, though glaciers can never have been more than unimportant features on even the highest of the Dinaric Alps. A glacier which continues to descend a main valley after those in the lateral glens have shrunk and ceased to be tributaries may have converted the latter into hanging valleys; its ice-stream may have replaced the rugged ends of spurs by smooth facets, but a river also, in similar circumstances, can produce the one and the other, and, in many cases, as Prof. Gregory shows, it can be proved that the valleys occupied by fiords are pre-glacial.

But, as he proceeds to point out, the larger features of fiords—the straight channels terminated by a sharp twist, the high angles made by tributary valleys, indicate a close connection with the greater earth movements which have determined the main physical features of the region. A set of diagrams bring out clearly the frequent relation between the fiords, the lakes, the mountain ranges and the shore lines in different regions, showing that the first and second very frequently follow the course of important faults. This seems indubitable, but we must remember that the work of the latter, though indispensable as a preliminary, has had an indirect, rather than a direct, effect in producing the present scenery. In regard to this a too frequent use of the term "rift valleys" may sometimes mislead: for a rift means a lateral rather than a vertical displacement, and should only be applied, as I pointed out in the *Geological Magazine* for 1905, where the surface is comparatively "raw"; for the "leading lines" in such an example as the Jordan Valley can only be discovered by close study of the geology. In such cases the older name, trough-fault valley, seems preferable. Apart, however, from this question of nomenclature, Prof. Gregory supports his view, both against ice-excavation and in favor of earth movements, as the primary cause of fiords, with arguments which will be very difficult to overthrow. But we must conclude, and do this by expressing our hearty thanks to him for this admirable history of fiords and other forms of inlets of the sea. It will be a great boon to students, for it is a veritable encyclopædia full of important facts, the collection of which must have entailed long and patient labor, because they are scattered about many publications in sundry languages, and often not readily accessible.

Fig. 1.—Map of Milford Sound, New Zealand.
From "The Nature and Origin of Fiords."

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En route to the North Cape. Skirting the precipitous cliff and narrow straits of Lyngenfiord, northern Norway.

*"The Nature and Origin of Fiords," by Prof. J. W. Gregory, F.R.S. Pp. xvi + 542 + viii plates. (London: John Murray, 1913.) Price 16s net. Review reproduced from *Nature*.

Coke Oven Gas for Lighting

It may now be safely said that those who, at a time when electricity supply began to become general, predicted the entire elimination of gas, with the gradual demolition of all gas works, have learned to realize that there is plenty of room for both these sources of energy. Recently, however, the future welfare of gas concerns has been causing renewed anxiety in certain quarters, and a different and to some extent plausible explanation is offered for the misgivings. The arguments now put forward relate to the rapid strides made by the coke oven industry in recent years, and to the possibility of this type of gas entirely superseding coal gas on the grounds of economy. Coke ovens, it is pointed out, enjoy unique advantages as compared with gas works; for, owing to the profits accruing from those materials which in gas works are looked upon as residuals, they have hitherto been in the position of finding their surplus gas something little short of a nuisance. Now, however, the management of these concerns is conducted with a watchfulness paralleled only by that of the gas engineer, and in consequence attention is being given to the profitable disposal of the spare gas.

So far as quality is concerned the coke oven gas can certainly be said to compare very favorably with coal gas from the standpoint of calorific power; but the recent practice of benzol "stripping" has not improved matters, and the gas would in most cases be unsuited for consumption in districts where penalties for candle-power deficiencies are in vogue. In Germany the distribution of the gas has been carried out on a fairly large scale, one of the chief centers of supply being Waldenberg, which provides for the greater part of the Silesian Plain by means of long-distance transmission systems. At Mülheim the company guarantees a minimum calorific power of 600 B. t. u. per cubic foot, but in this case only that portion of the gas evolved during the most favorable period of carbonization is diverted for town's purposes. The town authorities purchase this from the coke company, purify it from sulphuretted hydrogen and sell it to consumers at 2s. 9d. per 1,000 cubic feet, a price about four times that paid to the company.

Perhaps one of the most notable instances of coke oven gas replacing coal gas was the case of Ostend. In this town the municipality some two years ago concluded an agreement with a concessionary company for a supply of gas at a fixed rate of 10½d. per 1,000 cubic feet, and at the same time expressed their intention of demolishing the gas works as soon as the supply was started. So far as this country is concerned, however, a certain amount of caution has been displaced in the adoption of the gas, though a recent convert is the town of Middlesbrough, which is making arrangements for the whole of its supply to come from the adjacent ovens. Among other instances are Bargoed in South Wales and Little Hulton near Bolton, the latter being lighted by gas obtained from the Earl of Ellesmere's collieries. So far as the transmission of the gas is concerned, it seems to lose little of its value in traveling long distances, and in Germany pipe lines of great length have been laid.—*London Times.*

A Study of Earthlight.—The nocturnal illumination of the sky not due to stars or other heavenly bodies, and conjecturally ascribed to a permanent auroral glow (Scientific American, November 19th, 1911, p. 394), or to the bombardment of the atmosphere by meteoric material (Scientific American Supplement, June 15th, 1912, p. 370), is being made at the Mount Wilson Solar Observatory by P. J. van Rhyn. The observations of Yntema and Abbot as to the reality of the phenomenon have been confirmed, and the variations of the light with zenith distance, azimuth, and time are under investigation.

The Career of the Mining Engineer

His Schooling in Theory and Practice

By F. B. Richards

The average boy in high school has very little idea of the qualifications that are necessary for an engineering profession, yet in his first year he must make up his mind whether to take a college course or fit himself for any of the various technical schools he may decide to attend.

He may enter the leading technical school of the country and along with two or three hundred other boys take the general course of the freshman year, at the end of which he must choose one of the engineering courses, Civil, Electrical, Chemical, Mechanical, Hydraulic or Mining Engineering.

The average age of these boys about to enter their sophomore year and choose a technical profession is between nineteen and twenty. At this age the mind of the normal boy is somewhat immature, with generally preconceived ideas of all branches of engineering, which are to be somewhat shattered later. When he leaves school he starts out in the world with his degree in Engineering, and we will assume he has chosen Mining Engineering as a profession. He is a Mining Engineer in embryo, but let us digress and review what his ultimate development must be to reach a leading place in his chosen work.

Next to winning foodstuffs from the earth the mining of minerals from the earth's crust was one of the earliest vocations of man, and through all ages development has progressed slowly until the early part of the nineteenth century. Since the advent of steam and electricity and the coming of the trained mining engineer progress has been most rapid and the industry has to-day reached a very high state of development.

MINING ENGINEERS, TO WIN, MUST BE PHYSICALLY AND MENTALLY STRONG.

The most efficient and successful mining engineers of to-day are necessarily all-around men, physically able to go into the wilderness and the ends of the earth, if necessary; also mentally able to plan the attack of the largest of ore bodies by the most approved methods. These men must study carefully the geology of the location in which operations are about to be started, and if necessary to be sure of it, to make explorations by diamond or churn drilling and possibly test shafting, perhaps taking several months to a year or more in such work before a complete plan of operation can be reported to the owners of the property. This final plan must be most complete. It should show location of shafts, tunnels and open pits; the kind of machinery and power best adapted for extracting the ore, the facilities for transportation of supplies, the housing of men and a reasonable exact estimate of cost for the development of the ore body and a final approximate estimated cost of producing a ton of ore. If the ore should contain precious or semi-precious metals and must be treated by a milling process and the metals contained therein concentrated, the engineer should be able to either conduct tests to determine the most approved mill for the process or at least have knowledge enough to supervise such tests and reach a correct idea as to what process would be best. In the last few years the preliminary work of the mining engineer is perhaps best exemplified by the work done on the properties of the Utah Copper Company, Chino and Ray properties—great so-called porphyry copper deposits, where several years were spent in exploration, development and installation of machinery before a ton of shipping product was produced and the mines operated for months after starting before stable costs were attained. One of these properties, the Utah Copper Company, at Bingham, Utah, has produced and milled 20,000 tons of ore per day for weeks and months at a stretch, working an ore containing about 1.50 per cent copper and making a cost of something over eight cents per pound and at times less than this. This result has been possible only by most elaborate engineering work and the courage of the management to back the recommendations of the engineers with a vast amount of money.

These properties above referred to are immense bodies of copper-bearing rocks, where the mining engineer had first to determine the extent of the ore bodies, also the quality of the ore, and as they are operated largely through open pits, to determine the cheapest and best scheme mechanically to handle the ore in large quantities, also to design milling plants to treat an enormous tonnage daily with the best possible extraction of copper.

MINING OPERATIONS INCLUDE CAREFUL PRELIMINARY PLANNING

Unfortunately, we cannot all have open pits to work, in extracting mineral from Mother Earth, and the bulk of the mining of all minerals is through shafts and tunnels. The mining engineer, after his geological work is satisfactorily developed, must determine where shafts are to be sunk or tunnels driven. His preliminary development work should show him the best location, but it often happens the shaft must go through quicksand or bad ground and his ingenuity is often taxed to the utmost to make plans to get through it. After the ore body is reached, the opening of the same must be carefully considered. The points where levels and drifts shall be driven, the nature of the foot and hanging walls of the deposit should it be a vein or a lense, must be taken into consideration, as the question whether the hanging wall is firm and strong or treacherous and shattered may determine the mining methods to be pursued for the extraction of the ore.

The methods of underground mining will vary much with the conditions one finds. The common methods are timbering in square sets the entire ore body; by underhand stoping, overhand stoping or by opening up first the entire ore body by levels, drafts and sub-levels to the top of the ore and slicing out the ore from the top, letting the surface cave in, and follow the workings down as the ore is mined.

As the mine is operated, accurate maps must be kept of all the underground working, which means much underground surveying and work in the drafting room, if the property be a large one. Ventilation must be studied and provided for. This is of the utmost importance, especially in coal mines where there is a constant escape of gas from the coal into the workings. Anything but the best and most approved methods of ventilation used here would be criminal on account of danger of explosion and consequent loss of life.

The mining engineer whether in charge of a property or employed in a consulting capacity should be enough of a metallurgist and chemist to have a fair knowledge of the treatment of ores in the extraction of their metals and the cost of same; also the commercial value of ores in the markets. He should also be able to check estimates of contractors and pass upon their work to properly safeguard the interests of his principals.

From this brief summary of what is expected of a mining engineer, and it is largely superficial, as much more could be said of this profession and its ramifications, one can see that these men are trusted with vast enterprises and millions of dollars are invested in mining schemes on their reports and recommendations. Necessarily they must be of the highest integrity and honesty, and granting that they are all of this, they occasionally misjudge mining properties, generally when in their early stages, and cause losses to their backers. But this does not often happen with the highly trained man who has acquired in connection with his profession the practical knowledge of mining. There are black sheep in every profession and occasionally the engineer lends himself to promotion schemes by coloring his reports, but the majority in the profession are men of the highest type.

COLLEGE THEORY MUST BE SUPPLEMENTED BY PRACTICE.

Let us return to the embryo mining engineer who has just graduated. His fond parents feel that he must have a great career ahead of him and he himself thinks it should, after possibly the first year, be plain sailing to an ample competence. He goes to those people he may know in the mining industry, seeking of course a position as mining engineer or at least as an assistant engineer. He may succeed finally in securing a chance to assist the chemist in analytical work at some mine where considerable of this kind of work is required, and as chemistry has been part of his education he feels competent to do this easily, but would, of course, prefer to be the head engineer. His first day in the laboratory is a revelation to him; instead of the slow, careful work of the school laboratory, where he was taught theory with some practice, he sees what he considers slap-dash methods and hurried work, one man turning out forty to fifty analyses a day, and he is sure the work is inaccurate and against all his teaching. If he has a logical mind and is willing to begin all over again, he will find these methods are accurate but specially schemed out for rapid work. From this point on, if he is willing to keep his theory in the back of his head ready for use, and learn the practice of the laboratory, and furthermore if he has a fair amount of energy and is willing to work, he soon goes into the engineer's office, then underground on the survey, where he makes a friend of "Cousin Jack." He finds him a plain human man, with practical experience, and a good fellow. This same "Cousin Jack" will teach him a lot more and soon he is on the road to that competence.

As an illustration of what has been done, I know of a man who went through one technical school, specialized in another of higher grade, and when he graduated, in addition to his course in Mining Engineering, had taken a course in Electrical and Mechanical Engineering besides. He had been a fine student and had worked very hard for five years at college; he went to one of the leading mining engineers in this country, who secured for him "a job" in a mine in the West. He started mucking ore underground, that is, shoveling the ore into tram cars after it was blasted down, and it was hard work. In a short time he went into the mill, became later foreman; then chief engineer. He is now manager of a group of properties. Every proposition in engineering goes through his hands for approval and consideration. In addition to this he is responsible for the organization under him and the results obtained. It is needless to say the salary also fits the responsibilities.

From my own experience I feel that the man taking the course of Mining Engineering in any of the leading technical schools should realize that at best he is going to get all of the theory that he is able to absorb in connection with his profession, but very little of the practice, which he will acquire later in real work. He should be well grounded in mathematics, know his geology, chemistry, as much of mechanics as he can get, know enough of electricity and the appliance for its use as possible, and be competent in surveying, in addition to which he should acquire as much knowledge of the common metallurgical processes for extracting metals from their ores, and mining and milling methods as the text books can give him. After this it is entirely up to himself and his natural aptitude for this kind of a profession as to how fast he goes forward and how far he can ultimately go. He must have enthusiasm and love for his work and be physically able to stand the strain. In this profession the conditions in the various mining districts of the world are different and probably more varied than are met with by the men in any other engineering profession. There are new conditions arising all the time, even in old established districts where the geology is known and where methods have been worked out.

In conclusion he must be honest in his work or he will never become of real value to his employers and will not last long in his profession.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

Mnemonic Rule for the Constant π

In our issue of January 17th we quoted a French verse composed by Dr. Gerhard Kowalewski, the successive words of which, by the number of letters in each, give the successive figures of the value of the constant π, the ratio of the circumference of a circle to its diameter.

Several of our readers have sent in English verses which have the same property. We append these below:

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

The following English verse gives the first 31 digits of the constant π:

"See, I have a rhyme assisting
My feeble brain its tasks sometime resisting.
Efforts laborious can by its witchery
Grow easier, so hidden here are
The decimals all of circle's periphery."

Detroit, Mich. L. R. STOKELBACH.

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

Answering the question contained in the article "A Mnemonic Rule for the Value of the Constant π," SCIENTIFIC AMERICAN SUPPLEMENT of January 17th, I send you an English verse that I have made and that I have been using in the school for some time. I found it convenient to make the students remember the number π in 19 decimals:

3.1415926535897932384

Now, I have a score notations
Of digits large and small,
Teaching diameters precise relations,
And we can remember 'tall.

Kansas City, Mo. G. E. GUDE,
Teacher at the University High School.

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

In the SUPPLEMENT for January 17th, you published a French mnemonic rule for the constant π and asked for an English one. You will find two English ones in the English periodical *Nature* for October 5th, 1905, and a German one, as well as the French one, in the same for August 17th, 1905.

Washington, D. C. JOHN T. HEDRICK, S. J.

Construction of a 45-Ampere-Hour Storage Battery*

A Lead Accumulator of Simple and Durable Build

By Charles F. Fraasa, Jr.

If an electric current is caused to flow between two lead plates immersed in dilute sulphuric acid, a chemical action will occur. Peroxide of lead (PbO_2) is formed on one plate, and sponge lead (Pb) on the other. If the current is discontinued and the circuit between the two

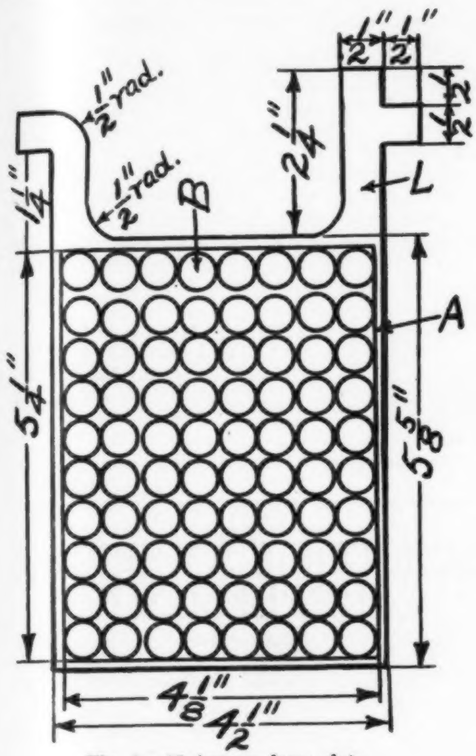

Fig. 1.—15-Ampere hour plate.

plates completed by a wire between them, a current opposite in direction to the original current will flow.

The current will be of short duration, however, since only the surface of the plates is affected by the chemical action. The capacity may be increased by what is known as forming; that is, giving the plates several charges and discharges. This develops more of the plate and makes a practical cell. Plates constructed in this manner are extremely durable, but excessive weight and expense of construction prevents an extensive application of this method of construction.

To lessen the expense of construction and reduce the weight, the plates are constructed of prepared lead. If two plates coated with lead oxide are substituted in the previous experiment, the current will convert the oxide on one plate to peroxide of lead, and the other into sponge lead.

The practical plate consists of a lead grid or framework, the interstices of which are pasted with the active material. The active material of the negative consists of litharge (oxide of lead) and sulphuric acid, and the positive of red lead. During the process of forming, the paste of the negative changes to gray lead; the positive to peroxide of lead. Gray lead is spongy and of a slate color. The peroxide has a velvety, chocolate-brown appearance, and is very hard.

The electrolyte consists of chemically pure sulphuric acid (H_2SO_4) diluted with distilled water. The specific gravity when charged is between 1,200 degrees and 1,250 degrees.

Storage batteries are usually constructed with an odd number of plates, there being one more negative than positive. This brings a negative at each end of a series of plates.

The chemical actions during the discharge of this formed cell are as follows:

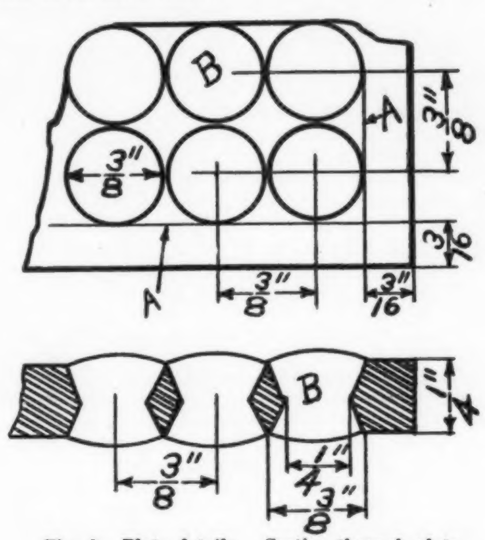

Fig. 2.—Plate details. Section through plate.

Negative:

$$Pb + H_2SO_4 = PbSO_4 + 2H.$$

Positive:

$$PbO_2 + H_2SO_4 = PbSO_4 + H_2O + O.$$

Adding the two equations:

$$PbO_2 + Pb + 2H_2SO_4 = 2PbSO_4 + 2H_2O.$$

In which Pb is the sponge lead, PbO_2 peroxide of lead, H_2SO_4 sulphuric acid, and H_2O is water. The water mixes with the electrolyte and reduces its specific gravity.

The lead sulphate formed during the discharge is a white powder of extremely low conductivity. If too much is formed, the internal resistance of the cell is increased and the efficiency is lowered.

The formula for charging reads:

$$2PbSO_4 + 2H_2O = PbO_2 + Pb + 2H_2SO_4.$$

The sulphate decomposes and combines with the water of the electrolyte, forming PbO_2, and Pb and H_2SO_4. This raises the electrolyte density, since water is taken from the electrolyte and sulphuric acid is added.

The chemical reactions are really more complicated, but the above fundamental formulas are, however, sufficient for a general understanding of storage battery operation.

The storage battery described in this article is of a simple and rugged construction. The capacity may be arranged to suit the builder; a three plate cell has a capacity of 15 ampere hours, and each additional positive and negative added increases the capacity by 15 ampere

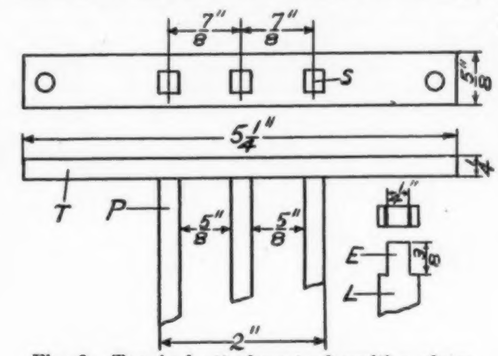

Fig. 3.—Terminal attachment of positive plates.

hours. Thus, a five plate (two positive and three negative plate) cell would have a capacity of 30 ampere hours, and a seven plate cell a capacity of 45 ampere hours. The voltage will average about 2 volts per cell.

The seven plate cell with a capacity of 45 ampere hours will be found very satisfactory for general purposes, such as lighting small lamps, operating motors and providing current for wireless coils, etc.

The plate is illustrated and dimensioned in Fig. 1. The material for the plates is 1/4-inch sheet lead. Procure enough of this to make the required number of plates. To facilitate the laying out of the plates, make a templet of thin sheet iron to the shape and dimensions of Fig. 1. A nail or sharp-pointed tool may be used to mark the outline, when the plate may be cut out, using a hack saw.

On each plate mark the 4 1/8 by 5 1/4-inch rectangle bounded by the lines *A*, which are 3/16 inch from the edge of the plate. This portion of the plate will contain the active material, which is placed in the holes, *B*, Fig. 2.

Starting 3/8 inch from the edge of the plate, scratch parallel lines 3/8 inch apart, both vertically and horizontally across the plate as shown in Fig. 2. The intersection of these lines locates the holes for the active materials. The holes, *B*, are drilled through the plate with a 1/4-inch drill, and then counter bored out to 3/8 inch in diameter on both surfaces of the plate. This is clearly shown in the sectional illustration, Fig. 2.

The active material is applied to the holes in the plates in the form of thick paste. This paste for the positive plates is made by mixing diluted sulphuric acid and red lead. The diluted sulphuric acid is prepared by mixing in an old dish 1 part pure sulphuric acid and 10 parts water. Then stir in enough of the red lead to bring it up to a thick consistency. It should be finely and evenly worked with a small wooden spatula to remove all lumps.

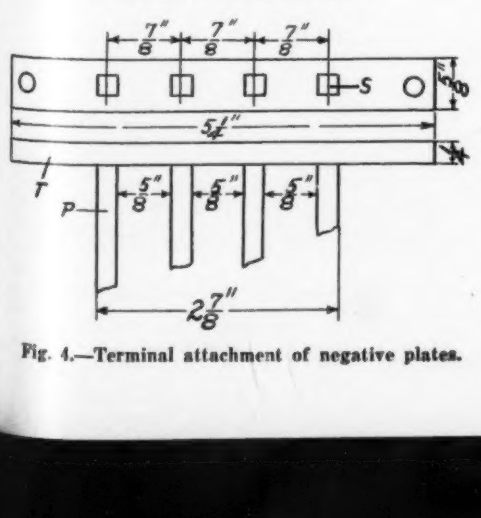

Fig. 4.—Terminal attachment of negative plates.

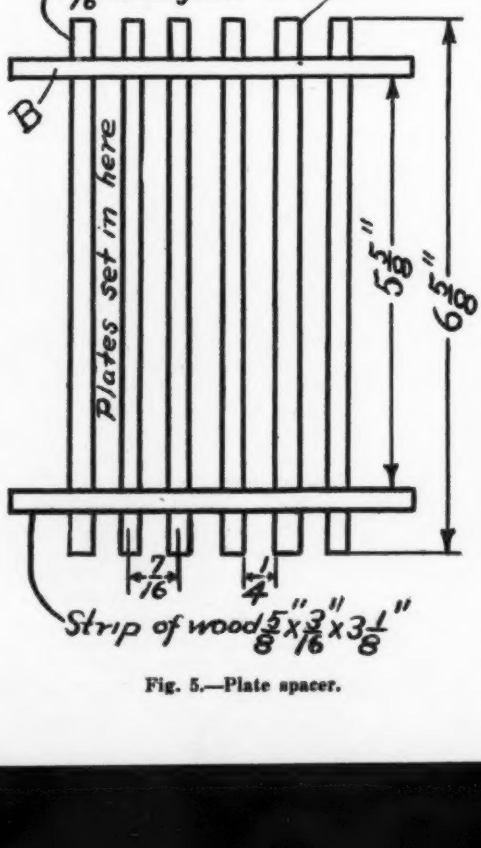

Fig. 5.—Plate spacer.

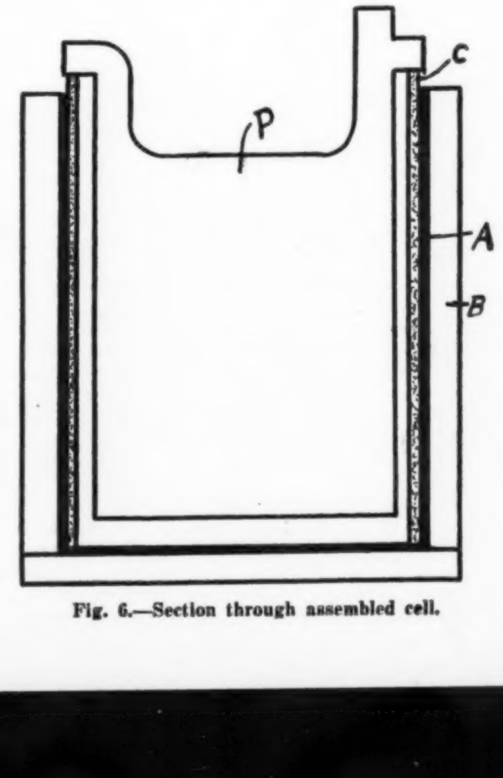

Fig. 6.—Section through assembled cell.

The paste for the negative plates is mixed in the same way, using litharge or yellow lead.

Three of the plates of each cell should be pasted with the red lead paste and the remaining four with the litharge paste. Force the paste well into the holes and flush with the surface of the plate. Lay the plates away over night to set and harden.

The three positive plates, *P*, Fig. 3, are connected to a common terminal, *T*, by inserting the top end of the plate lug *L*, Fig. 1, in slots *S* cut in the terminal strip *T*. The end of the plate lug should be cut in as shown at *E*, Fig. 3. When the plates are all in place in the terminal strip, fuse the terminal and lugs with a flame or soldering iron, using resin or tallow as a flux. A hole is drilled in each end of the terminal strip for connections. The four negative plates, Fig. 4, are assembled in the same manner.

The three positive plates are placed between the four negative plates. To keep the plates apart, glass tubes, *A*, Fig. 5, through holes in spacer blocks *B* are used. These rods are 3/16-inch glass rods 6⅝ inches long, spaced 7/16 inches apart. The blocks which hold and space the rods are hard wood, 3/16 inch thick, ⅝ inch wide and 3½ inches long, and should be boiled in paraffine.

The battery containing case, Fig. 6, is made of ⅛-inch sheet lead, cut and bent up from all four sides to form a rectangular box, open on top, having inside dimensions as follows: width, 5¼ inches; length, 4 inches, and a depth of 6⅝ inches. The four edges are fused together with a flame, or run together with a soldering iron and flux. This lead case, *A*, Fig. 6, has a hard wooden box, *B*, built around it. A piece of glass, *C*, 7⅛ inches long, is placed on each side of the box to keep the plates from contact with the lead case, which would short circuit them. It will be seen that the battery plates, *P*, are supported by the glass.

Pure acid and pure distilled water must be used for the electrolyte. The solution should contain about 1 part sulphuric acid, density 1,840 degrees, and 2 parts water. The density of the electrolyte will then be about 1,250 degrees.

The assembled plates should be placed in the battery jar, with the glass separating rods between them, and the electrolyte poured in until it covers the plates by about one half inch, when the cell is ready for forming.

Forming the plates consists in alternately charging and discharging the battery until the pastes on the plates have been converted to lead peroxide and sponge lead. The cell is charged and discharged about four or five times at the rate of about 6 amperes. The plate will not attain its maximum until this has been repeated from ten to fifteen times.

The ordinary recharge rate of this cell should be about 5½ amperes for 10 hours. The discharge rate will be from 5½ amperes to 5¾ amperes for 8 hours. Space prevents giving further data as to charging methods, for which the reader is referred to books treating this subject more fully than the writer could hope to in a short magazine article.

Baur's Silver Carbon Combustion Cell

The best steam engines convert into useful work barely 13 per cent of the latent energy of their fuel, and the corresponding proportions for large gas engines, and for the Diesel motor are only 25 and 35 per cent, respectively. Hence scientific men have long sought more efficient and more direct methods of converting the energy of fuel into work.

The first attempts to solve the problem were made with the thermo-electric element, in which an electric current is produced by heating the junction of two dissimilar metals. But this method offers no promise of a practical solution, for the thermo-element, in the most favorable conditions, transforms into work only one per cent of the energy of the fuel used in heating it, so that it is far less efficient than the steam engine.

Another possibility, less widely known, is found in the so-called "combustion" galvanic cell. The experiments that have been made with such cells have recently been discussed by Prof. Arndt in a comprehensive memoir, which is followed in this article. The essential characteristic of the combustion battery is the generation of an electric current by means of the oxidation, or combustion, of carbon. Herein it differs, for instance, from the sal ammoniac cells which are employed to operate electric bells. These cells contain electrodes of carbon and zinc, immersed in a solution of sal ammoniac, and in the working of the cell, the zinc is gradually consumed while the carbon remains intact. The same rule applies to the Bunsen and other galvanic cells in which carbon forms one electrode. The carbon remains unaffected while the other electrode, usually zinc, is oxidized and consumed. In the combustion cell, on the contrary, carbon or some other cheap fuel is consumed in the production of the electric current.

The first attempt to construct a combustion element was made nearly 60 years ago, by the great French chemist Becquerel, who fused saltpeter in an iron crucible and plunged rod of carbon into the hot mass. (High temperature is a necessary condition, as carbon does not combine with oxygen at atmospheric temperature.) When the carbon rod was connected with the iron crucible by a wire, an electric current flowed through the wire from carbon to iron, and the carbon was rapidly consumed. Despite this apparent success, however, the experiment yielded no useful technical result, principally because the operation of the cell was too costly, as the oxygen required for the combustion was obtained from saltpeter.

In 1896, Jacques endeavored to remedy this defect by employing atmospheric oxygen. He used a crucible 20 inches deep, filled with caustic soda, in which a rod of carbon 20 inches long and 3 inches thick was immersed. The combustion of the carbon was promoted by a blast of air blown into the fused soda. Prof. Haber subsequently proved that the current obtained was produced, not by the direct combustion of the carbon with atmospheric oxygen, but by a secondary reaction between the injected oxygen and the hydrogen which was evolved from the wet soda by the action of the hot carbon.

The announcement of this fact suggested the idea of constructing a cell for the direct combustion of hydrogen, eliminating the indirect double reaction with carbon and the employment of the comparatively costly caustic soda. From this idea was evolved the gas battery of Mond and Langer, composed essentially of porous plates, saturated with sulphuric acid, and coated on both sides with strips of platinum foil for the conduction of the current, and with platinum black for the purpose of accelerating the reaction. "A stream of combustible gas (hydrogen or cheap generator gas) flowed over one side, a stream of oxygen or air over the other side, of each plate. A cell having 700 square centimeters (108 square inches) effective electrode surface produced a current of 0.73 volt and 2 to 2.5 amperes, and utilized about 50 per cent of the hydrogen absorbed by the platinum. But the apparatus was too expensive and too irregular in action for practical use."

This unsatisfactory result has not deterred other experimenters from attacking the problem of the combustion galvanic cell. A notable advance toward the solution of the problem has recently been made by Prof. E. Baur, of Zurich, who utilizes the well-known and often annoying power of molten silver to absorb, and subsequently to evolve, large quantities of oxygen. Baur employs this property of silver in order to obtain a copious and long-continued supply of oxygen, and thus to enable his cell to generate a strong current for a considerable time without "fatigue," i. e., loss of efficiency. In all earlier combustion cells this defect was very evident, because the fused salt soon became poorly supplied with oxygen at the points where oxygen was consumed. Because of the high melting point of silver Baur uses, for fused salt, the difficultly fusible calcium silicate. About two pounds of silver are placed in the bottom of a large porcelain crucible and covered with a suitable quantity of calcium silicate. After both have been melted, a stream of oxygen is introduced into the molten silver by means of a porcelain tube, while the electric current is conducted from the silver by a nickel wire. Rods of carbon are immersed in the fused salt, above the silver. This cell is said to produce a current of 5 amperes for 5 hours. As the yield can evidently be increased by increasing the dimensions of the apparatus, it must be admitted that Baur's silver-carbon cell brings us a good deal nearer the goal, although we are still, as Baur himself points out, far from the technical and practical solution of the great problem.—[Adapted from Honus Guenther's article in *Technische Monatshefte*.]

Transparency of Leaves to Ultra-Violet Rays

M. Dangeard has studied the transparency of leaves to ultra-violet rays supplied by a mercury vapor lamp. He has observed, according to Prof. Mangin, that in a certain number of plants, particularly ferns, the leaves are much more transparent than glass for these rays. This is a somewhat remarkable result, if we consider that leaves have a complex structure. Begonia leaves and those of the China primrose have, on the contrary, the same transparency as glass for the ultra-violet radiations; moreover, there are other leaves that hardly let anything more pass than the extreme radiation of the visible spectrum more or less attenuated.—*Chemical News.*

Mountain Sickness

Some curious experiments on mountain sickness have been made by Dr. Guillemard, by the help of rabbits transported during the campaigns from the plain to the top of Mont Blanc, at an altitude of 4,800 meters, and to the Marguerite hut, situated at the top of Mont Rose, at an altitude of 4,560 meters. M. Armand Gautier remarks in the communication that he presents before the Academy, in the name of M. Guillemard, that the ureic nitrogen increases notably in the blood from the third day. The non-ureic nitrogen and the total nitrogen likewise increase. These phenomena seem to indicate that mountain sickness is the result of a nitrogen intoxication. The urea, a toxic substance that should be eliminated by the kidneys, is retained by the organism. It is thus a veritable poisoning that occasions mountain sickness.—*Chemical News.*

Tree planting on national forests has to be confined to comparatively short intervals in Spring and Fall. In Spring, it starts when the snow melts, and stops with the drying out of the ground; in the Fall, it comes between the Fall rains and first snowfall.

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